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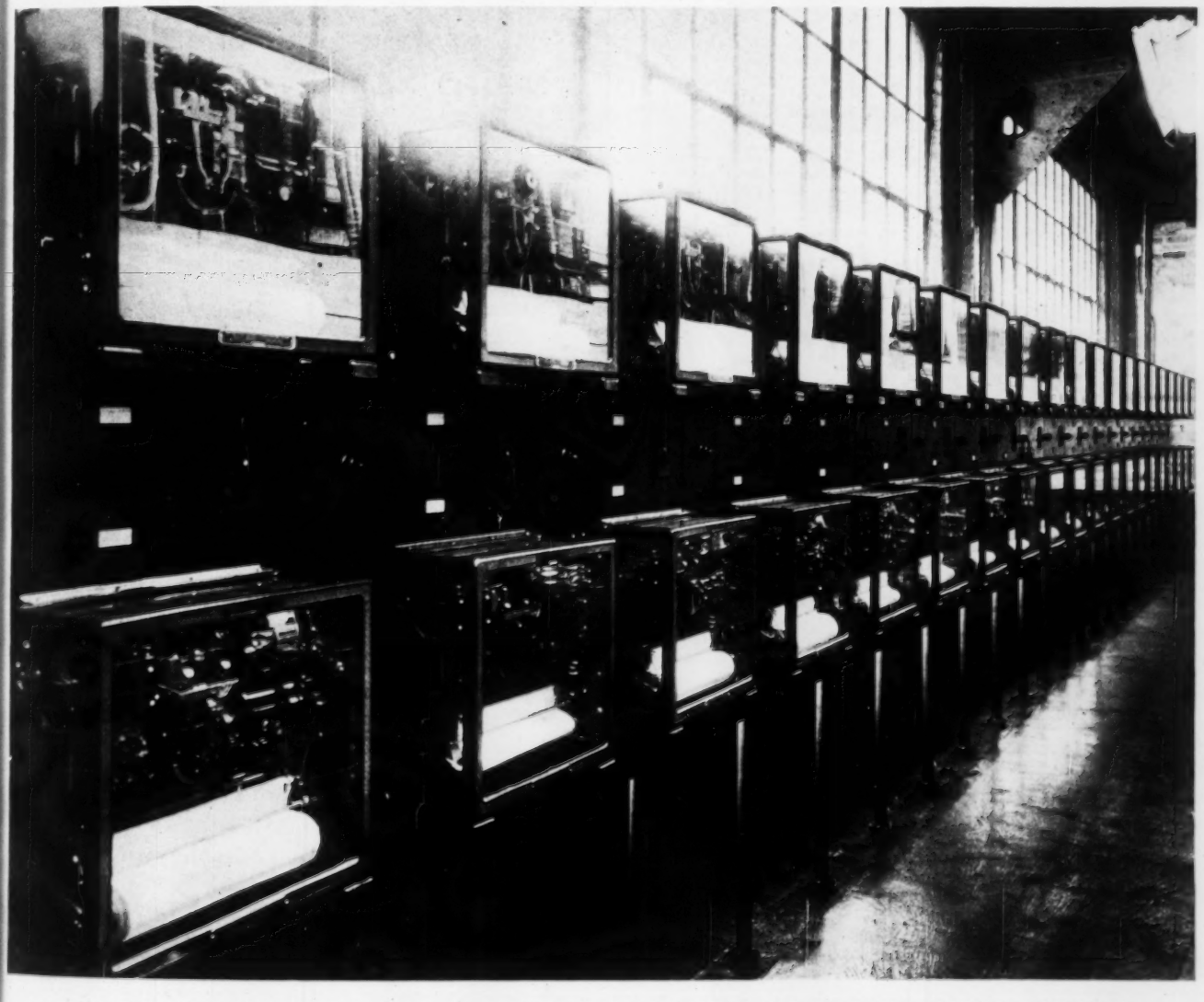
INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 7 APRIL, 1934 NUMBER 4



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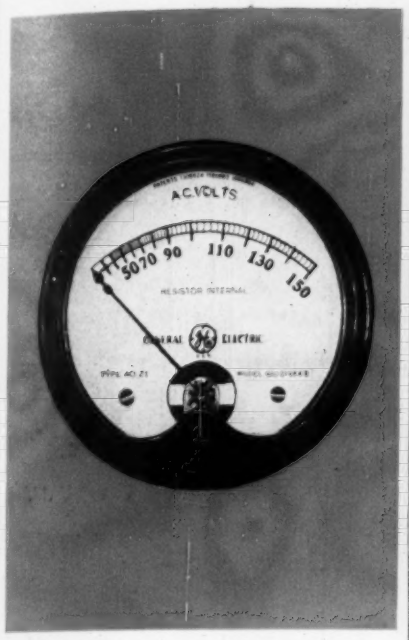

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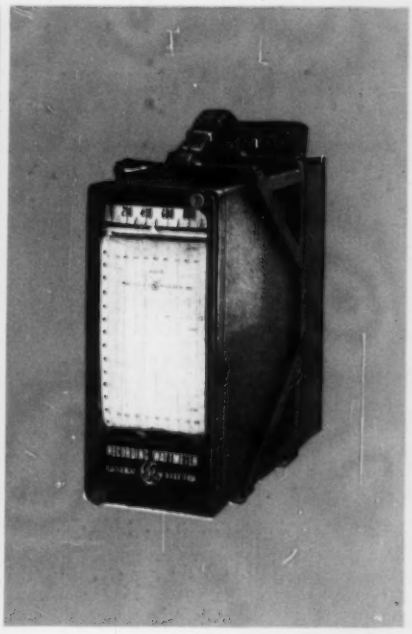

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INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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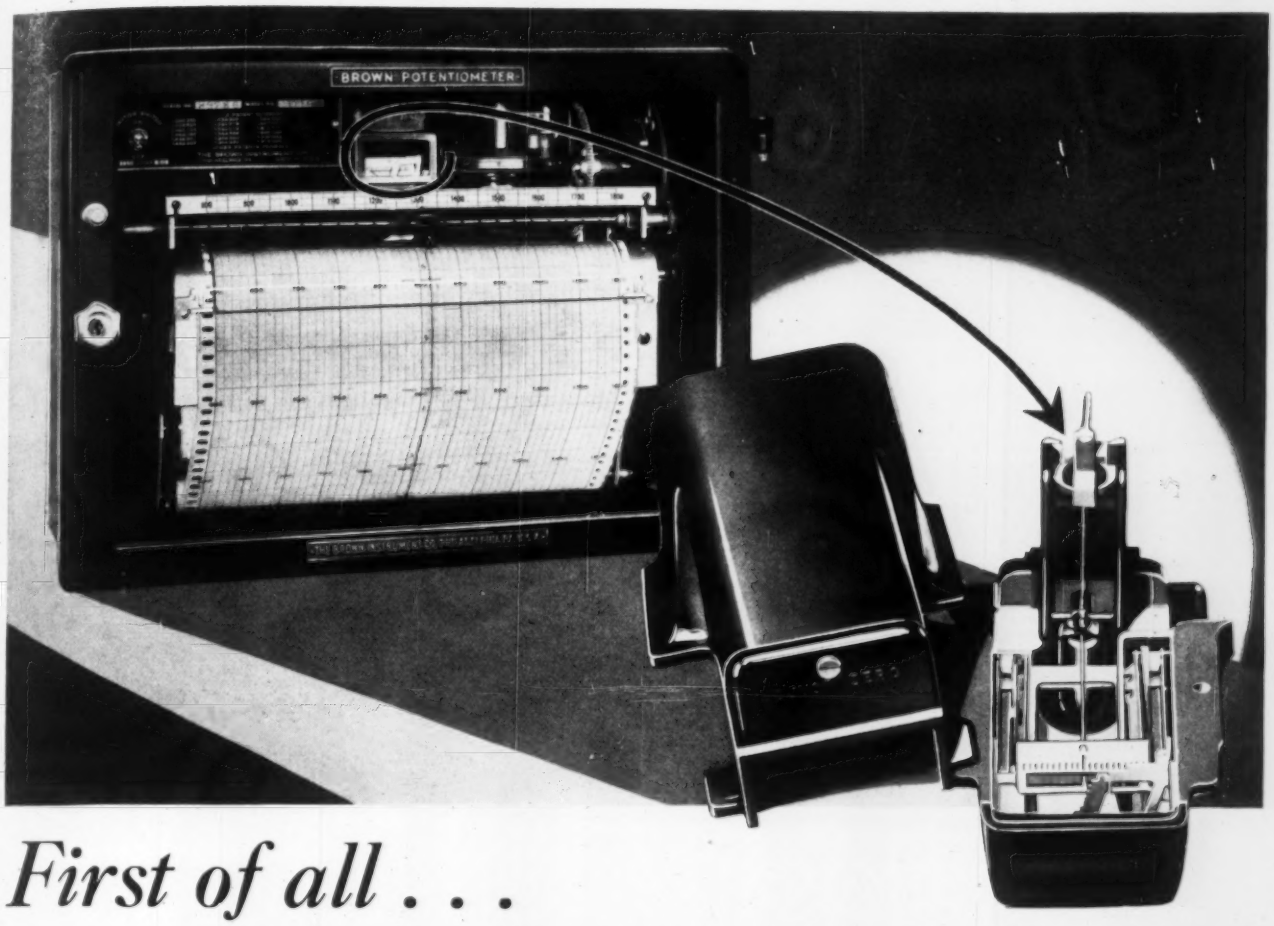

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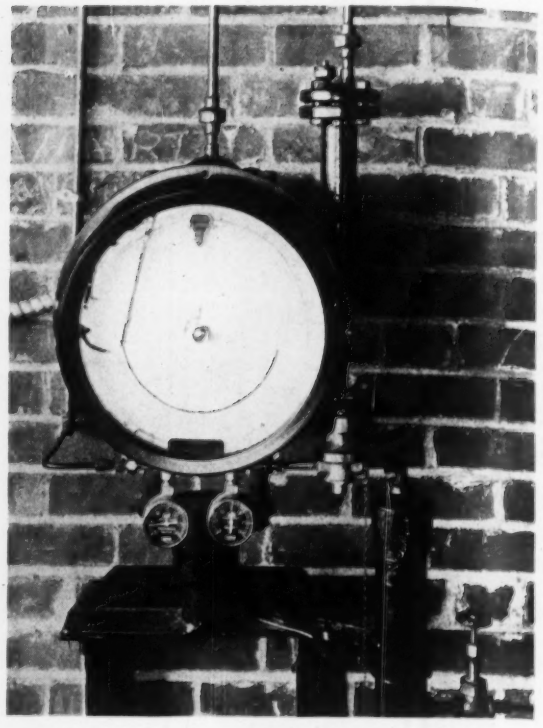

ONE OF OUR EXPERIENCES . . .

A Flow STABILOG at the Shell Refinery in Montreal

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EDITORIAL COMMENT

In This Issue

That public health is safeguarded by medical and surgical instruments is so obvious that it obscures a similar role played by instruments of the kind we all are interested in. **L. T. White,** in telling the story of Cities Service automotive service instruments, properly opens with an interesting "lead" on reducing the CO asphyxia hazard.

A new feature begins in this issue. See the main editorial.

In our electrical measurement series, a discussion of **Instrument Transformers** is suddenly introduced this month. Reasons: (1) Most electrical measurements nowadays are on a.-c. circuits, and (2) textbooks usually slight this subject and leave instrument users somewhat helpless. Score another hit for **Perry Borden.**

And as usual, quite a variety of **New Instruments.**

In Future Issues

Although the universal use of speed measuring instruments makes their accuracy particularly important, tachometer calibrating outfits are seldom used outside of instrument factories. **H. N. Hayward** describes a simple solution applicable wherever reliable-frequency a.c. is available.

We used to dismiss the measurement of power factor and capacity of dielectrics as an academic question, but on January 25th our eyes were opened at Session K of the A.I.E.E., where this subject fed the fires of lively discussions by authors and discussors of technical papers. **F. H. Benedict** has written one especially for *Instruments*, many of whose readers will find it of practical value, we know. We know it *now*. Live and learn!

The Front Cover

Many metallurgists and production men have traveled from afar to go through the heat treating department of the Oakland Motor Car Co. at Pontiac, Mich., where gears, pinions, shafts and other parts are normalized, carburized, hardened and drawn by the thousands with hardly a piece ever "going sour." All honor to the Oakland Motor Car Co.; all honor to The Electric Furnace Co. whose continuous furnaces make such an impressive sight; but let's go behind the scenes and enter a long narrow gallery where few visitors are admitted: it is the central control room and we find one of its walls lined with no fewer than forty Leeds & Northrup temperature recording and controlling potentiometers. . . . The success of *every* outstanding process development in the automotive industry is largely due to Instrumentation.

MADISON Square Garden at this writing houses GSOE. "Everybody" knows that GSOE means Greatest Show on Earth, says Dexter Fellows, waggish press agent who bestows superlative adjectives *à la* Barnum.

What would be the effect on the circus business if rigid statutes, enforced by honest agents, prevented anyone from publicly declaring anything to be "the greatest" unless so certified by authorities?

"Ruin!" would exclaim Dexter Fellows, with sincere conviction.

"Stability!" would vaticinate adherents of "there-ought-to-be-a-law" movements who believe, with equal sincerity, in censoring and regulating everybody and everything (except themselves).

But why accept any doctrine or dogma in this connection? Admiration for outstanding achievements is a normal human characteristic. Healthy interest in "record-breakers" makes for progress and the cynical "what of it?" attitude retards progress. A censorship on superlatives would be a nuisance from the start; it might degenerate into a dictatorship: compelling publications to glorify "teacher's pets" awarded championships under tricky rules.

No apologies, then, for inaugurating in this issue a pictorial feature devoted to record-breaking instruments: we launch it in the certainty that it will accomplish its dual purpose of (1) satisfying readers' normal and healthy curiosity, while (2) stimulating further progress.

During the last two years—especially in connection with the Century of Progress Exposition—photographs of record-breaking special instruments have come to our desk. They were not meant for the New Instruments Section and we could not use them elsewhere in the magazine. Nevertheless, most of them appealed to us so much that we put them in our "front cover possibilities" photograph folder, and more recently in a special folder—which, without a second thought, we labeled "Record Breakers." The idea of starting a new pictorial section then came as naturally as does your desire to tell your friends the good stories you heard on a trip. We wrote to the Bureau of Standards and other likely sources in order to gather a well-diversified collection, but there must be many other record-breakers which would interest *Instrument* readers. We want them.

Needless to say, quantity-production commercial instruments are out. This "singularity" rule must apply to any instrument, no matter how extraordinary, produced in any quantity greater than one. For example, THE 200-inch telescope qualifies as "the largest in the world" but if two were being built, neither would qualify. The simplest rule is the safest: only "world champions" get shown—no picture when there's a tie for first place.

Instruments does not propose to act as an Olympic committee deciding championships. We lack instruments for checking assertions, and shall accept the dimensions and characteristics duly reported to us.

Rule No. 2 is temporary: the first few issues will be limited to "the largest." Next year we shall start other classifications, but with caution. Some day (after buying a bullet-proof vest) we may print pictures of "the most sensitive."

Rule No. 3: Anyone who "puts one over" for selfish purposes will never get a second chance. On the other hand we shall not embarass anyone who makes an honest mistake. For example we have three candidates for "The Largest Spectrograph in the World"—nominated by a reputable individual, by a reputable company and by a reputable government bureau. All three nominators are not only scrupulous but conservative. Therefore, on a hunch that they simply used different yardsticks or had different types in mind, we started a friendly round-table discussion by mail—and now these distinguished men are all leaning over backward so much that we may never get permission to print pictures of

(1) the largest quartz prism spectrograph in the world,
(2) the largest diffraction-grating spectrograph,
(3) the largest echelon-grating spectrograph,
(4) the largest vacuum spectrograph,
(5) the greatest-resolving-power spectrograph . . . etc.

Anyway, this shows that we are getting splendid coöperation, thanks to which *Instruments'* readers will derive enjoyment and profit.

M. F. Behar

Exhaust Gas Analysis Promotes Gasoline Engine Efficiency

By L. T. WHITE*

RESEARCH and engineering can claim another victory in their constant warfare against menaces to life and health. This time it is carbon monoxide, that most insidious of all toxic gases, which is being vanquished. This battle is being won by means of a new weapon in the shape of a set of instruments. The "tactics and technique" of the employment of these instruments have been perfected by American oil industry research men. As is only too well-known, the toll of accidental deaths or cases of serious asphyxia from this cause was mounting in proportion to the increased use of the internal combustion engine—principally the automobile; and the principal danger resided in the exhaust gases. This danger is now greatly minimized by the Cities Service Power Prover discussed herein. This device nips the peril in the bud by reducing the generation of CO at its source—the engine.

Since CO results from inefficient combustion, it follows that if the efficiency is raised sufficiently, the CO content is lowered. The readers of *Instruments*, therefore, may be interested in the Power Prover from the engineering viewpoint, as well as from that of public health and safety.

The operator of a car, truck or bus, with gasoline in the tank and the engine started, becomes a manufacturer of power. As such he can be classed as relatively small and inexpert, for that function to him is both minor and secondary to his business. While oil companies are not engaged in the manufacture and sale of automobiles, they do supply the motor fuels and lubricants to the fleet operator to keep his vehicles running. Gasoline, in this instance, is purchased as a means to an end. The finest of motor gasolines, despite their many advertised claims, must give nothing but poor results in a badly adjusted engine. Gasolines now sold by major oil companies are pretty much alike. The quality of their performance rests entirely with the engine.

Urged forward by the desire to assist users of Cities Service petroleum products to obtain the maximum in power and mileage, our research engineers began in 1924 an intensive study of exhaust gas analysis under the theory that the faults of an engine could be traced through an analysis of the gases issuing from the exhaust pipe. Many of the known methods were tried. The most common of these were: analysis by thermal conductivity, combustion over catalytic gold- and glass-coated wires, successive absorption of constituents by chemical reagents, and physical methods on the basis of specific gravity. These methods were discarded as impracticable. A new instrument (or combination of instruments employing a new principle) was developed and christened the "Cities Service Power Prover." The particular problem met was the development of an instrument which, *in the hands of the ordinary mechanic*, would accurately determine the unburned fuel remaining in the exhaust gases.

Then, to correct the faults discovered through the tail of the exhaust pipe, a comprehensive 23-step tuning routine was developed and published to aid the mechanic in making convenient but correct motor adjustments.

*Automotive Research Dept., Cities Service Oil Co.

Flue gas analysis is not a new subject. However, the determination of the unburned fuel by quantitative analysis would have required a complicated process in the hands of an expert. Instead of such an analysis, it was decided that the practical method of burning the exhaust gases, and then carefully measuring the heat released, is a better and more usable one to follow. In consequence of this decision the Power Prover was designed to analyze exhaust gases by actually burning them and by indicating the unburned combustibles present in the exhaust and released in the apparatus through this burning of the exhaust gases. This, then, is not a chemical analysis.

Considering internal combustion from the angle of heat supplied, used, and wasted, Cities Service has a much simpler thesis than would be found in a chemical discussion: Gasoline of 20,000 B.t.u./lb. may be mixed with air in various ratios. We find that in the 9 to 1 ratio the engine makes 122 cu. ft. of gasoline-air vapor, and in 15 to 1 ratio 200 cu. ft. of vapor. As the heat units are supplied solely by the gasoline, the total heating value of the mixture remains the same, and with 9 to 1 ratios, we must produce a richer vapor than in the case of the 15 to 1 ratio.

Each cubic foot of vapor in the 9 to 1 ratio would contain approximately 172 B.t.u.'s, while in the 15 to 1 ratio there would be approximately 100 B.t.u./ft.^{3}. Therefore, as the air-fuel ratio is increased, the volume of vapor increases but the heat value per cubic foot of vapor decreases. This is set forth in table I which shows the soundness of the principle of determining the number of B.t.u.'s per cubic foot in the exhaust gases as a basis for reckoning combustion efficiency. Thus defined, combustion efficiency is the ratio of heat units consumed in the engine to those originally supplied.

An instrument which will analyze the potential heating value of exhaust gases, therefore, may take the form of an accurate, continuous, automatic calorimeter. In the Power Prover, the method of determining the number of B.t.u.'s per cubic foot of exhaust gases is briefly as follows:

A continuous sample of the exhaust gases is drawn to the Power Prover by either mechanical or water suction, depending on the type of unit used. These gases are first cleaned and cooled, by bubbling, to eliminate condensation; next they are dry-filtered. The sample is then reduced to a given quantity by delivery at a constant pressure and temperature. In relation to that given amount, air is admitted and mixed with it in a sufficient quantity to burn a gas of 87 B.t.u./ft.^{3}. The existence of such a gas would indicate a 50% combustion efficiency, the lowest efficiency for which the Power Prover is calibrated. The combined sample and air are thoroughly mixed, prior to ignition. To accomplish ignition of this extremely "thin" mixture, an unusual method was developed. The mixture is passed around a special platinum alloy wire, which is heated electrically. As the sample-air mixture passes this heated wire, combustion takes place through catalysis. This combustion is complete, hence readings based on it are reliable; it is relatively slow (i.e., not explosive) hence there is no danger of injury to life or limb such as there would be if an ordinary mechanic were given a laboratory to play with.

TABLE I—RELATION OF B.T.U. TO COMBUSTION EFFICIENCY

Air-Fuel Ratio (lb. air per lb. fuel)	Cu. Ft. per lb. Fuel: Gasoline Vapor	Cu. Ft. per lb. Fuel: Air	Cu. Ft. per lb. Fuel: Total Inlet Mixture	Btu. in Fuel Supplied per Cu. ft. of Inlet Mixture	Btu. per Cu. ft. of Exhaust	Btu. Consumed in Engine	Combustion Efficiency Per cent	Classification of Mixture
9 to 1	5	117	122	172	86	86	50	
10	5	130	135	158	69	89	56	Rich
11	5	143	148	144	51	93	64	
12	5	156	161	132	38	94	71	Range of Correct Mixture
12½	5	163	168	126	31	95	75	
13	5	169	174	121	23	98	81	
14	5	182	187	112	13	99	89	Lean
15	5	195	200	100	0	100	100	

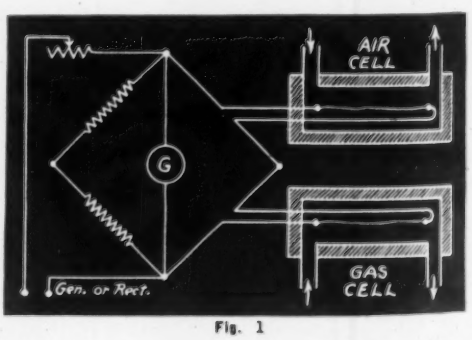


Fig. 1

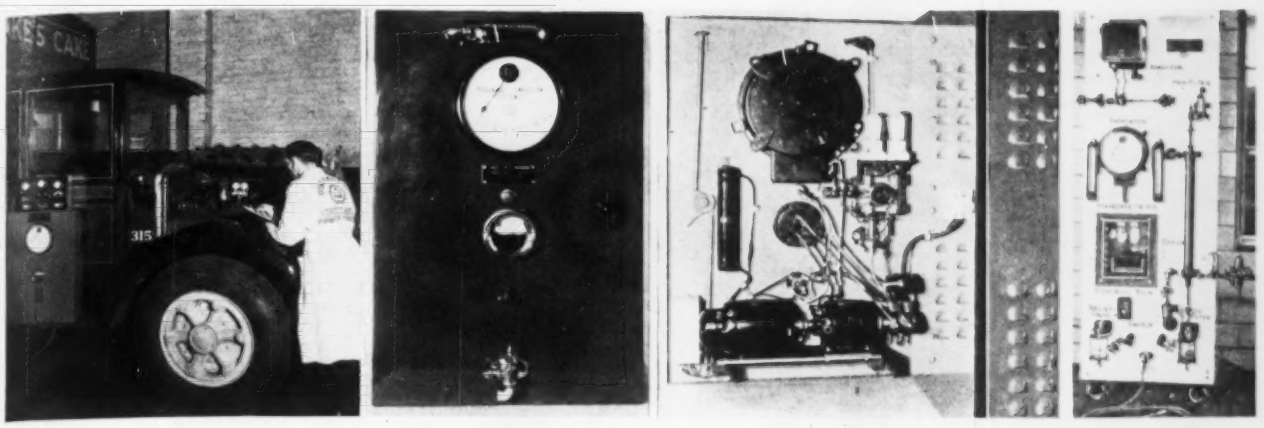


Fig. 2. LEFT—Instruments in use by Drake Bakeries: new model Power Prover and Ignition Tester on running board and Compression Leakage Tester on engine. CENTER—Panel and parts of 1934 model portable Power Prover. RIGHT—Wall type Power Prover and accessories.

The calculation of the amount of potential fuel present in the exhaust gases can be said to be accomplished electrically, by employing in combination two well-known thermal effects: (1) the conversion of electrical energy into thermal energy when a current flows in a conductor of *fixed* resistance, and (2) the *increase* in the resistance of a conductor when its temperature is increased by application of heat from an external source; and by employing the well-known Wheatstone bridge for obtaining a galvanometer deflection, that is to say a pointer-and-dial indication that the ordinary mechanic can read.

Fig. 1 shows the essential elements of the Power Prover analyzer and its simple bridge circuit, with a catalytic combustion cell through which the sample passes and a comparison cell through which air alone passes. The galvanometer deflection represents unbalance due to the greater resistance of the exhaust gas cell but its scale is graduated for convenience in percent combustion efficiency, the null point being, of course, marked 100% (no unburned fuel). The analyzer may be checked by passing through the exhaust gas cell a few cubic inches of a standard gas mixture (supplied in high-pressure steel bottles with reducing valves). This standard mixture, when burned, produces a galvanometer deflection corresponding to a fixed percent efficiency, and the simple one-point calibration may be made by anyone by turning an adjusting screw until the pointer stands at this calibration mark on the percent scale.

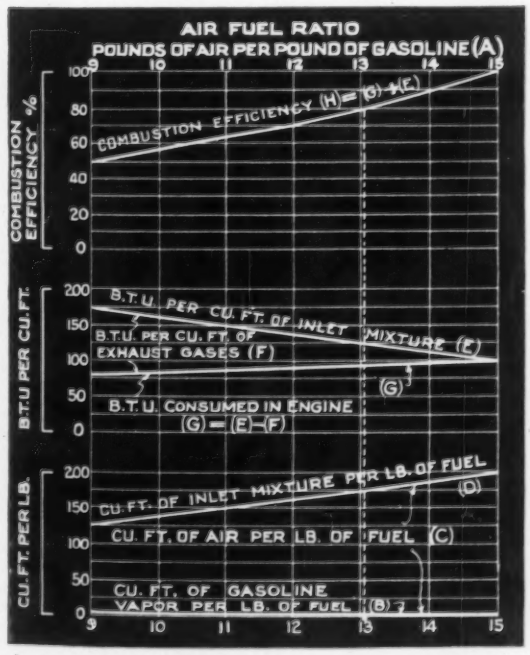

AIR FUEL RATIO
POUNDS OF AIR PER POUND OF GASOLINE (A)
9 10 11 12 13 14 15
COMBUSTION EFFICIENCY %
100 80 60 40 20 0
COMBUSTION EFFICIENCY (H) = (B) ÷ (E)
B.T.U. PER CU. FT.
200 150 100 50 0
B.T.U. PER CU. FT. OF INLET MIXTURE (E)
B.T.U. PER CU. FT. OF EXHAUST GASES (F)
(G)
B.T.U. CONSUMED IN ENGINE (G) = (E) - (F)
CU. FT. PER LB.
200 150 100 50 0
CU. FT. OF INLET MIXTURE PER LB. OF FUEL (D)
CU. FT. OF AIR PER LB. OF FUEL (C)
CU. FT. OF GASOLINE VAPOR PER LB. OF FUEL (B)
9 10 11 12 13 14 15

Fig. 3. Chart on which Table I is based.

OUTLINE OF ROUTINE

The operator of the Power Prover, having attached the sampling tip to the exhaust pipe, reads, within 30 seconds, the combustion efficiency of the engine; its ability to convert into mechanical energy the heat energy supplied. The next thing to do is to proceed to correct faulty conditions after determining their causes. A systematic tuning routine was devised to go with the Power Prover tune-up set which includes, besides the gas analyzer, a set of specially designed tuning instruments. After the vehicle under test has had its engine combustion efficiency determined, it is put through a rigid tune-up, which covers practically all of the vital components of its motor, including electrical system, valves, pistons, rings, timing and carburetor. Perhaps the use of this service can best be made clear by outlining its application to a typical motor vehicle.

When the car is presented for a test and tune-up, a record of the car and its motor is taken. This includes the make, serial number, model, year and mileage. The make and type of motor is also noted, including ignition system, carburetor and fuel system. A carefully compiled bound book of data sheets in the hands of the operator assists him in making the various specified adjustments.

With the motor running, the sampling tip is attached to the exhaust pipe, and initial combustion efficiency readings taken at both idling and various running speeds. The operator knows in advance that the optimum combination of performance and economy is obtained with combustion efficiencies of between 75% and 85%, depending upon the type and condition of the motor. Should the initial reading register above this, for example, 90% to 95%, he would consider the possible causes as:

(1) That the air-fuel ratio was providing too lean a mixture.

(2) That the mixture was being diluted through air leaks in the intake manifold system, or around the stems of the intake valves.

(3) That the valves were leaking. Defective intake valves allow spent gases to be driven into the intake system on exhaust strokes, which impair fuel mixtures. Defective exhaust valves permit redrawing into the cylinder of spent gases on suction strokes.

(4) Leaks in the exhaust pipe, through aspirator action of the exhaust gas stream, would dilute the exhaust sample.

When the operator encounters a reading below the proper range, for example, between 50% and 60% (and these cases are by far the most common) he knows that the motor is not properly burning its fuel. Guided by this knowledge, as to general faults, he proceeds with the tune-up routine.

In all cases, the condition of the lubricating oil in the crankcase is determined. When found deficient in sealing property, replacement with fresh oil will improve combustion efficiency 5% to 15%, as it improves the piston seal, and hence the compression.

The spark plugs are next removed and tested under air pressure corresponding to the maximum compression encountered in the engine. If acceptable, the plugs are cleaned, adjusted to specified gaps with feeler gages, and are ready to be restored to the engine.

Next a test is made of the ability of each cylinder to hold compression. This is accomplished by using the Cities Service Compression Leakage Tester. This exclusive instrument (seen

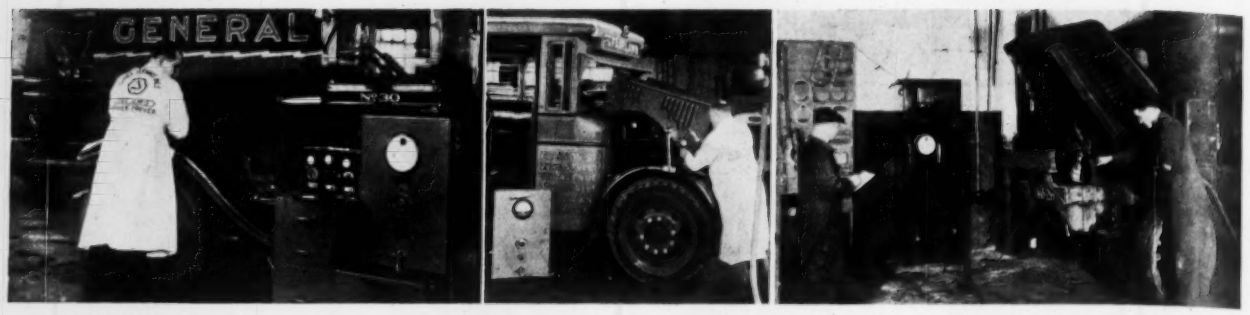


Fig. 4. LEFT—Ignition test (General Electric Co., Cleveland). CENTER—Stroboscope and tachometer (Fairlawn Transportation Co., Paterson, N. J.). RIGHT—Carburetor adjustment (Mulligan Trucking Service, New York City).

in Fig. 2 left) consists essentially of a calibrated capillary orifice, one side of which communicates with a chamber in which a constant pressure is maintained by means of a regulating needle valve and a gage especially calibrated for various engine bores. The other side is connected to the cylinder to be tested. The leakage in this cylinder, past piston and valves, determines the pressure on the downstream side of the orifice, which is measured by another pressure gage. This gage bears arbitrary graduations which classify the condition of the cylinder tested as good, fair, or poor, depending upon the pressure that the cylinder is able to maintain.

The spark plugs are removed and the Leakage Tester is connected between a compressed air line (>75 lbs./in.^{2}) and the cylinder to be tested. The piston in this cylinder is brought up on the compression stroke to top dead center and the stream of air is admitted. If the rings or valves leak, the pressure within the cylinder will be less than that in the compressed air line; there will be a continuous flow through the orifice and the two gage readings will differ. The operator can then rate each cylinder as to its degree of leakage: there always is *some* leakage, of course, and consequently the Leakage Tester bears arbitrary graduations to guide the operator.

This method, conducted while the motor is silent, frequently locates the point of leakage. Air leaking through the intake valves may be heard in the intake manifold or carburetor; leaky exhaust valves may be heard in the exhaust manifold; leaky rings may be heard at the breather pipe. (Recently, a stethoscope has been furnished as an additional instrument: service station customers are convinced when they hear the roar of air escaping past leaky points in their engines.) If valve leakage is present, the tappet clearances are first checked up. Then if valve re-grinding is necessary, an immediate job is suggested. If, on the initial readings, the motor was shown to have abnormally high readings at high engine speeds, the cause frequently is due to valve bounce at high speeds, due to weak or "fatigued" valve springs. After such indications, the tension of each valve spring is readily noted by another exclusive instrument, which compresses the spring and indicates the pressure on a dial. Weak or defective springs are recommended to be replaced.

Next the motor is carefully timed. Timing on the vast majority of cars encountered is found to be defective. On one series of 1,800 cars checked as to timing, only 20 were found correct. In the procedure, timing is adjusted from exact piston positions (determined by another special instrument) and the circuit breaker and distributor mechanism are carefully examined, and worn or defective parts replaced. At this point the plugs are replaced in the motor and it is warmed up to normal running temperature.

The next step is to verify the engine's timing at various speeds and here again it is found that exact timing adjustments made while the motor was stationary frequently do not hold true, especially under high speed conditions. This, in some cases, is because of lag through wear of the mechanism; or through failure of the spark governor or automatic advance to function, or to function evenly as speeds are increased.

Speed timing is checked with a specially developed neon timing lamp, connected in series with the secondary ignition system, which provides stroboscopic illumination so that marks placed on the flywheel and case, or the fan pulley and radiator, can be studied at high speeds. If found faulty, correction by adjustment or replacement is made.

The coil is tested by means of a special instrument embodying a variable spark gap, connected between the coil and the distributor. If the current is found ample and jumps the gap, the coil is assumed to be sound. The condenser is checked for dielectric strength with an instrument which indicates grounds, shorts or defective insulation. Supplementing this, the secondary wiring is gone over with a neon pencil which, when traced along the wire, flashes when a broken or defective wire is encountered. Such wiring is replaced. Various models of ignition testing instruments are optional, ranging from the simplest to those shown in Fig. 2 (left) and Fig. 4 (left).

At this point, when all adjustments to the ignition have been made, a second Power Prover test of combustion efficiency is made. If it is found that correct efficiency is still lacking, the carburetor is then adjusted. Under this procedure, it is interesting to note that a great majority of carburetors need little manipulation, whereas under ordinary methods the carburetor is usually "adjusted" before the other factors incidental to combustion have been touched.

In adjusting the carburetor, the operator is generally aided by constant references to his analyzer dial. If the pointer moves away from the desired efficiency (75% to 85%) he is making the wrong adjustments. If it moves toward it, he is on the right track. After the motor has been brought to its proper efficiency, the driver of the vehicle is asked to give it a brief road test to make sure of its starting, power, pick-up and performance. The instances where readjustment is asked for are remarkably rare.

It is interesting to note that more than 4300 fleets have taken advantage of this Power Prover Service. Hundreds of thousands of vehicles have been tested. Minor adjustments, inaccurately made, were in most cases causing losses of from 10 to 30% of the gasoline used in these vehicles.

As the Power Prover is also an accurate guide to the need for overhaul, the mileage interval between maintenance operations has been greatly lengthened. This results in greatly lowered maintenance costs, in addition to the decreased operating costs through the savings of gasolene and oil.

The Willett Company of Chicago, operators of 450 buses and trucks, reports that 70,000 gallons of gasoline have been saved since adopting Power Prover service.

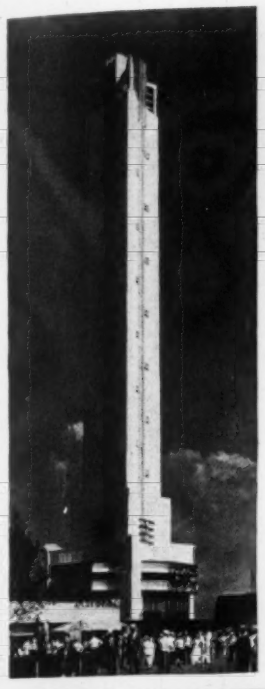
The illustrations accompanying this article include but a few more of the many large fleet operators who have taken advantage of Power Prover service. (The Power Prover itself is not sold.) Attention is invited to the demonstration cars sent out on a nation-wide educational tour sponsored by Cities Service Oil Company.

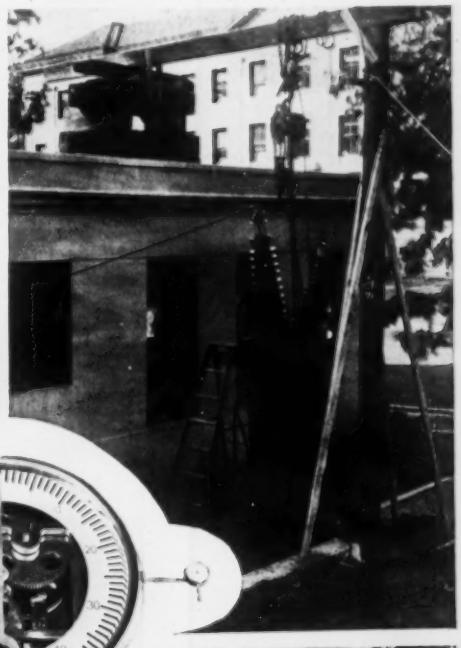
Fig. 5. A special kit of service tools may be seen on the bench near the new model Power Prover.

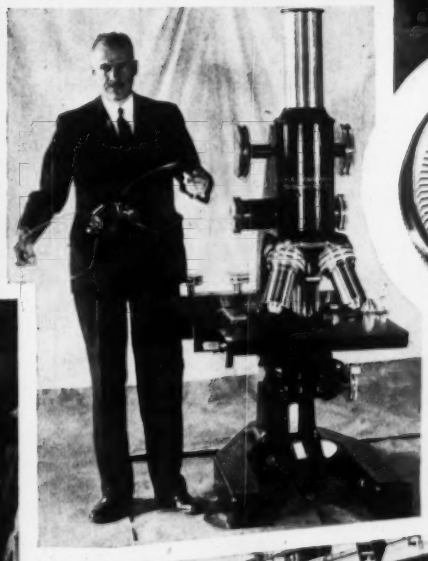
Fig. 6. One of the traveling exhibits, equipped with projection screen and numerous instruments.

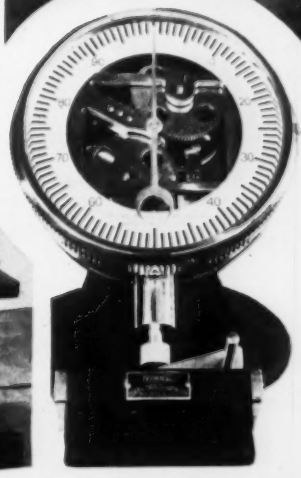
"RECORD BREAKERS"

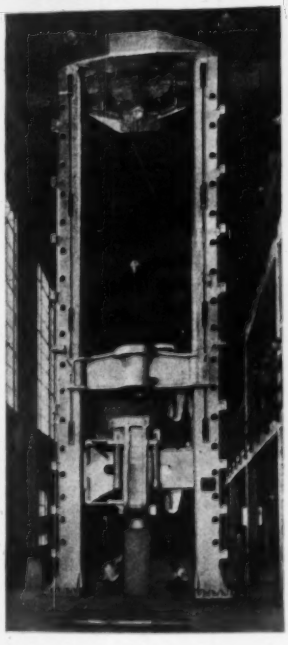
A New Pictorial Feature See Editorial

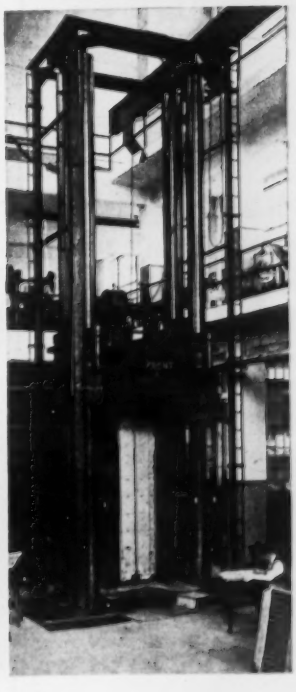


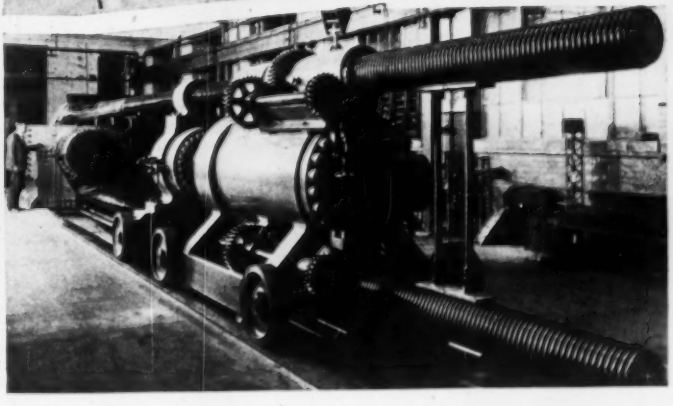












Upper left. World's largest "straight form" thermometer—the Indian Refining Co.'s 218-foot tower at Chicago. Each of the three sides resembles a V-case spirit thermometer, red neon tubes end-to-end (covering 2° each) furnishing the illusion. Thermal system is mercury bulb (in shade outdoors) operating helix which actuates a follow-up and commutating mechanism which in turn operates heavy-duty relays closing circuits of proper number of neon sections. C. C. Schweiso, designer; O. B. McClintock Co., builders of mechanism.

[Last minute P.S.—*The New York Times*, April 8, reports that a "red electric line" thermometer has recently been built on one side of the Eiffel Tower in Paris. The Chicago instrument, we think, still retains the championship of the "separate" or "independent" class.]

Upper center. World's largest "dial form" thermometer (22-foot diameter) is on Atlantic City boardwalk. Liquid-filled helical spring thermal system controls electric motor drive of 9½-foot pointer. The Brown Instrument Co. designed and built mechanism for The Electric Storage Battery Co.

Upper right. Probably the world's largest instrument transformer, being tested at Bureau of Standards, Washington, for a 132 kv. system in California.

Left center. Carl L. Bausch, Director of Research of Bausch & Lomb Optical Co., demonstrates what are probably the largest eyeglasses and largest microscope model.

Right center. World's largest dial indicator (13" diameter) built by Federal Products Corp. for Franklin Institute, Philadelphia. At its side is a 1" diameter Federal indicator for comparison.

Lower row shows three record-breaking testing machines: The largest vertical type in point of dimensions, built by Baldwin-Southwark for the University of California, is at the left, while at the right is the largest-capacity (10,000,000 lbs.) at the Bureau of Standards; and between them is the largest high-precision hydraulic type, also at the Bureau of Standards, taking a 34-foot specimen and reading a 2,300,000-lb. load with an error of only 2 or 3 lbs.

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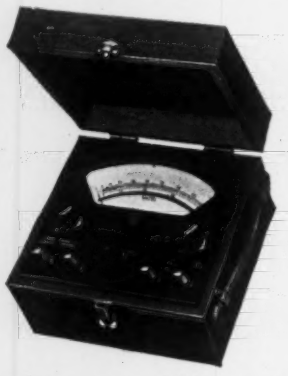

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Instrument Transformers*

By PERRY A. BORDEN† and M. F. BEHAR**

1. Definitions and Classifications

Before dealing in greater detail with the classes of instruments which make use of the types of measuring elements already described, it now becomes necessary to interpose a brief treatment of those important accessories known as instrument transformers. This treatment, as it goes into details, is largely based upon manufacturers' special publications.

First of all, just what is "a transformer"?

A transformer is a piece of apparatus without continuously moving parts, which, by electro-magnetic induction, transforms alternating or intermittent electric power in one circuit into alternating or intermittent electric power in another circuit, usually at different values of voltage and current. (A.I.E.E. Standard Definition.)

From this definition it appears that transformers are only employed in a.-c. work. It is not a case of a mere definition: the reason there are no d.-c. transformers is that an apparatus capable of "stepping up" or "stepping down" voltage or current must include a means of producing or utilizing *relative motion* of electrical conductors and magnetic fields. In d.-c. work, involving a continuous flow of electricity, it is necessary to produce this relative motion if we want transformation without waste, and the apparatus usually takes the form of a motor driving a generator. In a.-c. work, where every conductor has associated with it a continually changing field, it is possible to construct simple devices wherein advantage is taken of this continual change. Therefore, in electrical measurement and control technology, "an instrument transformer" is always understood to be a device for the transformation of alternating currents.

There are two definite classes of instrument transformers, the current transformers and the voltage transformers. By reason of structural differences which are beyond the scope of this book to discuss, it is impracticable to construct a universal instrument transformer, suitable for both purposes.

A *Current Transformer* is a transformer, intended for measurement or control purposes, designed to have its primary winding connected in series with a circuit carrying the current to be measured or controlled. (A.I.E.E. Standard Definition)

A *Voltage Transformer* is a transformer intended for measurement or control purposes, which is designed to have its primary winding connected in parallel with a circuit, the voltage of which is to be measured or controlled. (A.I.E.E. Standard Definition.)

The terms "primary" and "secondary" distinguish the windings in regard to energy flow, the primary being that which receives the energy from the supply circuit, and the secondary that which receives the energy by electromagnetic induction from the primary.

There are two other "general classes" of instrument transformers, dry and oil-insulated. Dry-type voltage transformers are ordinarily constructed for primary voltages up to 6600 volts, and the oil-insulated type for higher voltages. Current transformers are ordinarily constructed for primary currents up to 10,000 amperes. For voltages up to 23,000 volts, the dry-type current transformer is used, and for the higher voltages the oil-insulated type.

There are also, of course, "indoor" and "outdoor" instrument transformers, and other possible classifications; but since all instrument transformers—in spite of their importance—are auxiliary devices, there is no need of going into any other methodical classifications. Section 7 on "Special Types" deals with varieties of interest to instrument and meter users.

2. Specific Functions

Instrument transformers in alternating-current measuring circuits may be said to perform *five* functions, as follows:

(1) Most importantly, they permit the measurement of large and small electrical magnitudes with instruments of identical construction.

(2) They permit the measuring instruments to be electrically insulated from dangerous voltages.

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*Fourth chapter (XXXII) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook will be published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

†Member A.I.E.E. **Editor, *Instruments*

(3) They permit the instruments to be located at any convenient point, not necessarily adjacent to the circuits under measurement.

(4) Because of the relatively low current and voltage values in the instrument circuits, the wiring is simplified and made less costly.

(5) In some instances, finally, they permit the combining of currents or voltages for measurement purposes in a manner that could not be done with the main circuits.

The primary voltage and current windings of instrument transformers are made suitable to the circuits upon which they are intended to be used, while the secondary of a voltage transformer is generally designed for about 115 volts and that of a current transformer for 5 amperes with rated full load current flowing. It is customary, wherever possible, to ground permanently the secondaries of instrument transformers as well as the cases of the instruments to which they are connected. In polyphase groupings any point of the secondary may be grounded, but it is preferable to use a neutral point or a common wire between two transformers

3. Polarity

The standard polarity of instrument transformers is the same as if the primary service conductor itself were detached from the transformer and connected directly to the secondary conductor. In other words, in the connection diagram, the instrument transformer may be treated as though it were replaced by a resistor. Corresponding terminals of the primary and secondary windings of modern instrument transformers are distinctly marked in accordance with the above standard.

Polarity Check on Current Transformer. Connect an ammeter in the marked primary lead, and connect the secondary as shown in Fig. 32-1. With the unmarked secondary lead connected to "*a*", put a known alternating current

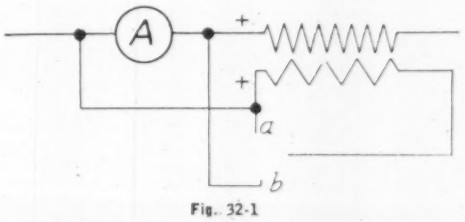

Fig. 32-1

through the primary winding and read the ammeter. Then connect the unmarked secondary lead to "*b*", put the same current through the primary and read the ammeter again. If the second reading is larger than the first, the markings are correct. In making this test care must be taken not to open the secondary circuit while current is flowing in the primary.

Polarity Check on Voltage Transformer. Connect together the marked end of the high voltage winding and the marked end of the low voltage winding, and excite the transformer by applying any convenient alternating voltage to the high voltage terminals. Measure the voltage applied to the high voltage winding, and the voltage between the unmarked ends of the two windings. It the latter reading is less than the former the polarity markings are correct.

4. Principles of Operation of Instrument Transformers

Since the accuracy of measurement accomplished with an instrument supplied through an instrument transformer is dependent upon the relation between magnitudes in the primary and the secondary circuits, it is essential that the ratio and phase-angle be maintained with great constancy under all conditions to which the transformer may be exposed. In order that possible sources of error may be understood, it is well to make a brief study of the operating principles and characteristics of instrument transformers.

(a) Voltage Transformers.

The voltage transformer, in principle, is an ordinary constant potential transformer especially designed for close regulation, so that the secondary voltage under any conditions will be as nearly as possible a fixed percentage of the primary voltage.

The secondary voltage can never be exactly proportional to the primary voltage or exactly opposite to the primary voltage in phase, on account of the losses in the transformer and the magnetic leakage between coils. This is shown by the vector diagram, Fig. 32-2.

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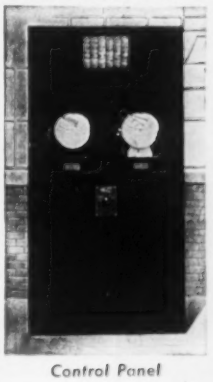
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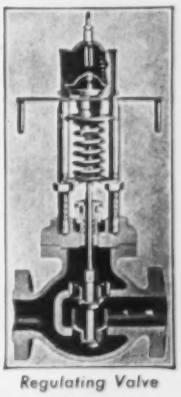
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INSTRUMENTS BOOK SHELF

Instrument Flying. By HOWARD C. STARK. James Stark, Pawling, N. Y. 1934. Cloth, 5x8 inches, 77 pages, 25 figures. Price $2.00.

In brief this little volume covers the technique of using aircraft instruments during flight when the ground is not visible, based on the author's unique and long experience in instrument flying and on his own experiments. The instruments considered essential for this purpose are the airspeed meter, the altimeter, the turn and bank indicator, the compass, the directional gyro, the rate of climb indicator and the Sperry artificial horizon. The best arrangement of these instruments on the instrument panel is discussed. The functions of the instruments during instrument or "blind" flying are simply but authoritatively stated. The radiobeacon service maintained on airways is described and its use in maintaining the proper direction during flight between airports is outlined. The method of locating a radio beam, and uniquely identifying it when the pilot is lost in one of the quadrants, is covered in considerable detail. The particular procedure developed by the author for finding the beam is emphasized. Many precautions and many items of useful information on the adjustment and use of the instruments are given from the viewpoint of the pilot.

The author covers the narrow field of the use and functions of the instruments. The few deviations into a description or performance of the instruments which occur are somewhat hazy from the viewpoint of the instrument engineer. For example, no definite information is given on how to determine when a magnetic compass is "slow," which condition is defined as unsatisfactory. The time for the compass card to swing from, say, 30 to 5° from a heading 30° off the meridian, and other laboratory data for both satisfactory and unsatisfactory compasses, appear reasonably essential to the discussion. The statement that the directional gyro has a "precession" which may amount to several degrees in an hour is understating considerably the amount which usually occurs.

The book is useful to the aircraft instrument engineer in giving a concise presentation of the function of the instruments from a pilot's viewpoint. The emphasis upon the function of the instruments is in striking contrast to the emphasis of the engineer upon the principles of operation and the performance.

A study of the book will benefit all beginners in instrument flying and even pilots practiced in the art.

—W. G. BROMBACHER (9)-B-

The Engine Indicator—Its Design, Theory and Special Applications. By K. J. DEJUHASZ. The Instruments Publishing Co., New York, 1934. Cloth, 5½x8½ inches, 240 pages. Domestic price $3.75, including a year's subscription to *Instruments*; foreign price $5.00 for same combination.

Everyone who has taken a technical course—whether the full curriculum or even a brief practical course—remembers that books on engine indicators filled a whole shelf in the school or university library. Some of us remember also that these books dealt with the steam engine indicator and that they echoed one another. Seldom referred to nowadays by practising engineers, these old books are of little more than historical interest. The time was ripe for a modernized treatment of modern indicators for the users of high-efficiency steam and internal combustion engines developed since 1914. This is it.

But it is much more: it is a mine of valuable information not only for engineers in power plants, pumping stations, truck and bus fleet shops, engine factories and automotive and aeronautical research laboratories—not only for

(Continued on page 72)

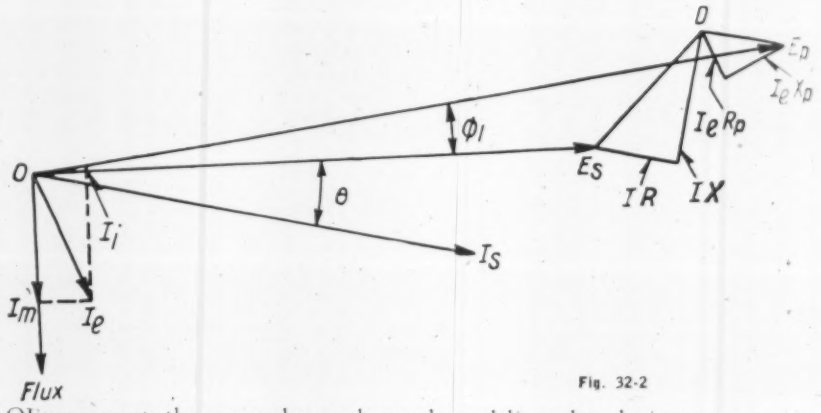

Fig. 32-2

OE_s represents the reversed secondary voltage delivered to the instruments.

OI_s represents the reversed secondary current delivered to the instruments.

θ represents the angle of lag of the secondary current behind the secondary voltage and is determined by the relation of resistance to reactance in the instruments.

OI_i represents the current in the primary winding to supply the iron loss of the transformer (hysteresis and eddy currents).

OI_m is the current to magnetize the core.

OI_e is the total exciting current: the vector sum of OI_i and OI_m. It flows in the primary winding only.

IR is the voltage drop due to the load current I_s and the resistance of both primary and secondary windings. It is parallel to OI_s.

IX is the reactance drop due to the load current and is perpendicular to OI_s.

OD would therefore be the primary voltage if the iron required no exciting current. But the exciting current, flowing in the primary coil only, causes a drop in voltage.

I_eR_p is due to the resistance of the primary coil and is parallel to OI_e.

I_eX_p is due to the reactance of the primary coil and is perpendicular to OI_e.

OE_p therefore, represents the total primary voltage necessary to deliver the load current OI_s at the secondary voltage OE_s. It differs from OE_s both in magnitude and in phase position; and

ϕ_1 represents the phase angle between primary and secondary voltages.

Thus, there are two classes of errors inherent in voltage transformers: ratio error and phase-angle error. The part of these errors due to the exciting current is constant for any particular voltage. It can be minimized by choosing the best quality of iron and working it at a low magnetic density. The part of the errors due to the load current varies directly with the load and can be minimized by making the resistance and reactance of the windings low—not necessarily "as low as possible" for then we might impair some desirable feature.

In any transformer (voltage or current) the *Ratio Error* can be neutralized for one particular condition of load by "compensating" the transformer. This means that the actual ratio of turns differs from the marked ratio of the transformer by an amount just sufficient to make up for the voltage drop at the specified load.

Phase Displacement Error. The effect of the phase displacement of the secondary voltage need not be considered when using voltmeters, frequency meters, synchroscopes, or protective and regulating relays, which depend on voltage only. With wattmeters, watthour meters, and similar instruments, whose indications or registrations depend not only on the voltage but also on its phase relation to the line current, the phase error has some effect.

The effect of the phase displacement cannot be compensated for in the transformer, as it depends not only on the constants of the transformer, but on the power factor of the load to be measured as well.

In general, both ratio and phase angle error are very small in first-class voltage transformers, and may be neglected in most commercial measurements. If accuracy is required, ratio and phase angle curves must be obtained for the particular transformer in use at the particular load condition which exists, and correction must be made.

(b) Current Transformers.

The ordinary voltage transformer or distribution transformer is connected across the line and the magnetic flux in the core depends upon the primary voltage. For a given voltage, therefore, the flux is fixed, while the current in the winding rises and falls as the load of the secondary winding changes.

The current transformer is connected directly in series with the line. For a fixed number of instruments in the secondary (which is the usual condition) a rise or fall in the line current requires a corresponding rise or fall in the secondary voltage to force the secondary current through the impedance of the burden. The magnetic flux in the iron, which supplies this voltage, thus follows the rise and fall of the primary or line current.

In any transformer, the primary ampere-turns may be considered as made up of two parts, one small component which supplies the magnetizing and core loss current, and another component which supplies the "working current." The "working current" ampere-turns are always exactly equal to the secondary ampere-turns. For the current transformer, these components may be shown graphically as in Fig. 32-3.

The total primary ampere-turns are represented by OI_p. The exciting current is represented by OI_e and the primary "working current" by OI_s. The secondary ampere-turns OI'_s, are exactly equal and opposite to this element of the primary current. It is readily seen that OI_p is the vector sum of OI_e and OI_s.

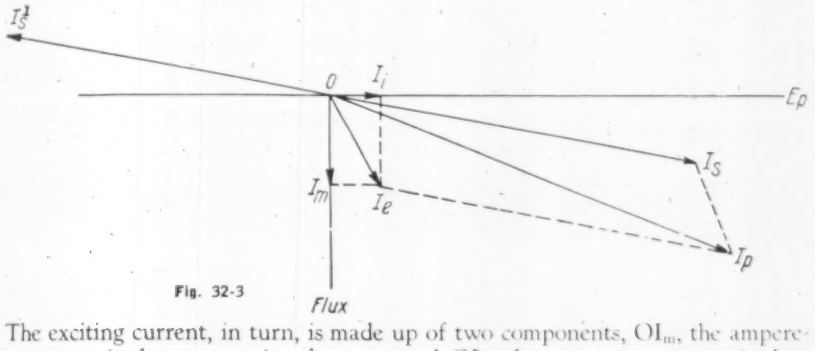

Fig. 32-3

The exciting current, in turn, is made up of two components, OI_m, the ampere-turns required to magnetize the core, and OI_i, the ampere-turns required to supply the hysteresis and eddy current losses in the core. These vectors show the phase relation of the various currents.

As generally used, the current transformer "steps down" from a large current to a small one, so that the primary winding consists usually of few turns and the secondary of many turns.

Inherent Errors—If the exciting current in Fig. 32-3 could be reduced to zero, the secondary ampere-turns would equal the primary ampere-turns and would be exactly in phase opposition. The transformer would then produce a current in the instruments which, under all conditions, would be proportional to the line current and in exact phase opposition to it. From Fig. 32-3, it will be noted, however, that there is a ratio error, since the vector OI_s is not quite equal in length to the vector OI_p; and, also, a phase displacement, since the vector OI_s is not exactly in phase opposition to the vector OI_p. The losses in the core are the disturbing elements which cause both of these inherent errors.

In order to show vectors of magnetizing and core loss currents, it is necessary to exaggerate them considerably, for the iron loss elements are actually small. The diagram gives a good idea of the effects of these elements, but not of their measure.

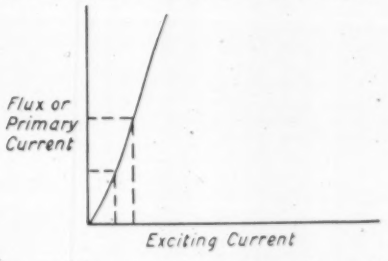

Fig. 32-4

Ratio Error—If the exciting current decreased exactly in proportion to a decrease in the primary current, all vectors in Fig. 32-3 would decrease in the same ratio, and the per cent ratio error and the correction factor would be constant for all primary currents. However, from Fig. 32-4, it will readily be seen that at a flux density corresponding to one-half normal primary current, the exciting current is more than one-half of its value at full primary current. This component, therefore, forms a disturbing element and attains relatively large proportion as the primary current decreases.

Phase Displacement Error—The phase displacement, like the ratio error, is a function of the core losses. These losses are relatively greater as the primary current decreases. The phase displacement error has no effect on an ammeter, which simply measures the amount of current without regard to its phase posi-

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564

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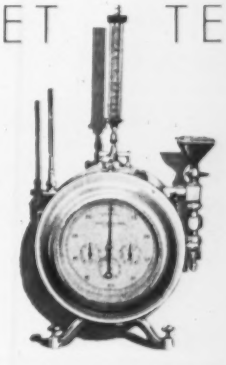

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BOOK SHELF—Continued from page 70

these but for all engineers who have to investigate *forces* and *motions*, and particularly for engineers who may not have the least interest in engines but who are concerned with *variable pressures*.

Although the author made the improvement of indicators his principal work for many years (developing the DeJuhasz Indicator as well as others not bearing his name) his recent years as Assistant Professor of Engineering Research at Pennsylvania State College have evidently been largely devoted to finding new uses for what he calls "normal types" of indicators for special applications. His book should prove useful in every shop and laboratory where variable pressures have to be known. Firearms people who deal with extremely high pressures lasting a thousandth of a second, ammonia-compressor people who deal with comparatively slow variations, and many other classes of technicians, will all find Prof. DeJuhasz talking straight to them in their own language and telling them of ingenious methods they all can use profitably.

One reads this book with delight and astonishment at the remarkable advances made in recent years, and with admiration for the author's lucid presentation of every conceivable angle of his subject.

The figures are numbered up to 132 but many numbers are supplemented by letters up to g or h, so that there are something like 300 separate illustrations, which add to the clearness of the text and greatly increase the value of the book for busy engineers.

—M. F. Behar (2.09)-B-

The Electric Home. E. S. Lincoln. The Electric Home Publishing Co., New York, 1933. Cloth, 6x9 inches, 454 pages. Price $2.00.

Mr. Lincoln, a member of *Instruments'* Editorial Advisory Board, has written this book for people who want to get the most use out of electric service in the home. The author takes his reader through every room in the home, explaining each household task that electricity can lighten and every situation where electricity can make life more livable. The reader is shown the need for various electrical appliances, how each piece of electrical equipment works and how the user can use the appliance most efficiently. Home wiring systems, fuses, meters, lighting equipment, water heating, clothes laundering, house cleaning, air conditioning, electric cookery, food preparation, electric heating appliances, clocks, outdoor uses for electricity—are some of the topics covered.—Richard Rimbach

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Erhardt C. Koerper, formerly Sales Manager of Streeter-Amet Co., is now filling that capacity with Gaertner Scientific Corp., Chicago, and assisting Mr. William Gaertner, Pres. After receiving an engineering degree in the University of California, Mr. Koerper attended the Harvard Graduate School of Business Administration. *Instruments* readers will remember his article on "Automatic Weight Recording" in the November 1932 issue.

Emilio N. MacKinney has been appointed sales representative of Sarco Co., Inc., New York City, for Mexico City. Mr. MacKinney, a Mexican, is a graduate of M. I. T.

Walter D'Arcy Ryan, General Electric illuminating engineer, regarded as the man who first made artificial illumination both a science and an art, died at his home in Schenectady, March 14, of heart trouble, at the age of 63.

The New York office of the **American Meter Co.** will be moved on April 23 from 105 West 40th St. to the Lincoln Bldg., 60 East 42nd St.

tion. It has some effect, however, on instruments such as watt-meters, and power-factor meters whose indications depend not only upon the amount of current but also upon its phase relation to the line voltage. By referring to Fig. 32-3, it will be seen that the reversed-secondary current OI'_s leads the primary current OI_p by a small angle. This is the usual condition.

5. Characteristics in Use with Instruments

The electrical characteristics of the circuit into which an instrument transformer supplies energy are what is known as the *burden* on the transformer (the term *load* is not used here). In the ideal transformer the ratio under all conditions would be the value marked on the device by the manufacturer, and the phase-angle between primary and reversed secondary voltage (or current) would be zero. While modern advances in instrument transformer design have made for distinct approaches toward the ideal, it still is necessary, in precision measurement, to make allowances or corrections for such errors as di

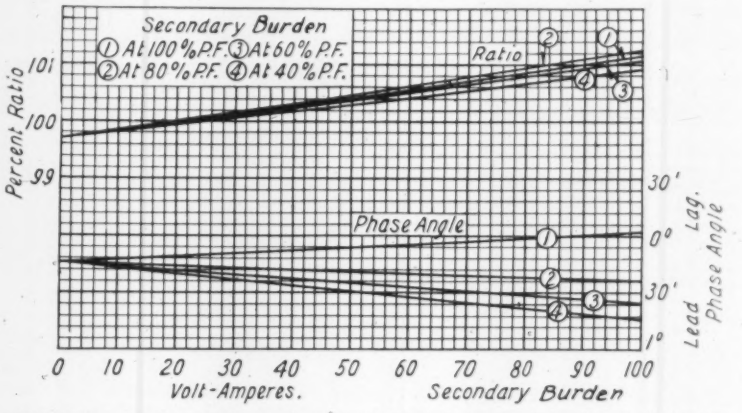


Fig. 32-5. Ratio and phase angle curves of dry-type voltage transformers: ratio 40 to 1, 25 cycles (Westinghouse).

exist. Characteristics of different types of instrument transformers, while generally similar, differ to such an extent that no curves can here be given which would be suitable for use in making the necessary corrections. Curve sheets can be obtained from the manufacturers of the transformers, or the characteristics can be determined by the use of special testing equipment.

Corrections for instrument transformer characteristics must generally make allowance for the secondary burden, imposed by each particular type of instrument, especially when several instruments are connected. The value of this is expressed either as total ohms impedance, or as the total volt-amperes and power factor of the secondary devices and leads. This value is sometimes roughly but conveniently expressed as being the equivalent of certain specified instruments of known characteristics.

Manufacturers usually publish, for each of their standard models, sets of curves from which the user can conveniently take the most important data required for computing these corrections. Figs. 32-5 and 32-6 are two such *characteristic curves*, the first for a particular type of voltage transformer and the second for a particular current transformer (both Westinghouse).

6. Precautions in the Use of Instrument Transformers

In the use of instrument transformers it becomes necessary that certain precautions be observed; and these are considered below:

(a) Voltage Transformers

Since the voltage transformer in its performance is practically identical with the power transformer, it is imperative that the secondary terminals never be short-circuited when there is any possibility of the primary being or becoming energized. In case of short circuit an abnormal current will flow, with the possibility (frequently the certainty!) of burning out the windings. Some makers recommend the use of fuses in the primary line to voltage transformers; but, owing to the high voltage and small current in the circuit, it is found that such protection is not dependable. Some users connect the high voltage side directly to the supply line, but this practice is attended with hazards. Probably the safest practice in the protection of voltage transformers consists in the use of a fuse combined with a properly proportioned series resistor.

In the performance of tests it is important that a voltage transformer connected to a supposedly dead supply line be not energized from its secondary winding; for in such a case the high voltage set up in the primary winding will be applied to the supply line, and an extremely hazardous condition introduced.

In a high grade voltage transformer it may safely be assumed that the ratio and phase-angle characteristics, once determined, will be permanent under any conditions which do not damage the transformer.

(b) Current Transformers

In the use of current transformers, while high voltages do not normally appear between the terminals of either winding, it is important that the insulations between the primary and the secondary, and between the primary and ground, be suited to the voltage of the circuit on which the transformers are to be used. The most important precaution to be observed in the use of

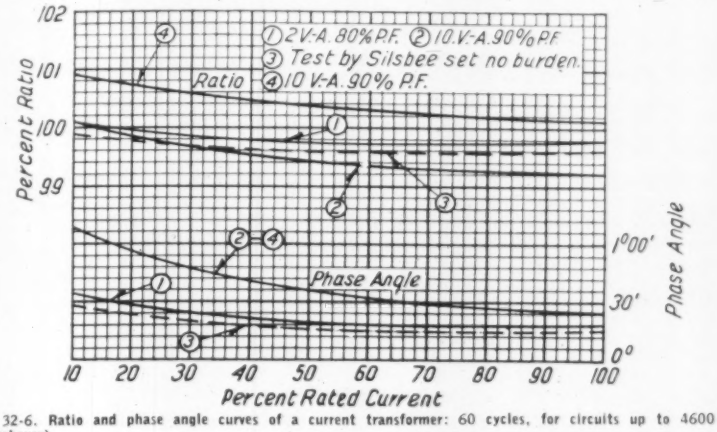


Fig. 32-6. Ratio and phase angle curves of a current transformer: 60 cycles, for circuits up to 4600 volts (Westinghouse).

current transformers is that *the secondary circuit should never be opened* when the primary is carrying current, and that it should never be left open when current is likely to be passed through the primary. Non-observance of this precaution is likely to produce any or all of four undesirable conditions:

(1) There is developed between the secondary terminals a difference of potential which may prove hazardous or even fatal to any person coming in contact with the instruments or leads.

(2) This voltage, having a very peaked wave-form, is also likely to break down insulation, either in the transformer or in associated circuits.

(3) The abnormally high value of flux produced in the core when the action of the primary ampere-turns is unopposed by the secondary ampere-turns, even for a portion of a cycle, may permanently change the magnetic condition of the iron, so that the accuracy of the transformer will be impaired.

(4) The iron losses due to the high flux in the core, if operation is continued with an open secondary, may produce enough heat to damage the insulation of the transformer.

From the above it will be seen that an open-circuited secondary is the unforgivable sin in the use of current transformers, and the only safe measure is to keep the secondary short-circuited at its terminals whenever the winding is not definitely and positively connected to a complete circuit of suitably low impedance. Many current transformers are provided with short-circuiting switches or links, and the careful instrumentician will not hesitate to make use of them.

The precautions against operating current transformers with open circuited secondary windings apply in the making up of circuits; and, where several current transformers are interconnected, it is imperative that there be provided a complete return circuit for the resultant of their secondary currents.

If the secondary circuit of a current transformer is accidentally opened under load, or if the past magnetic history of the transformer is not known, possible magnetization of the core should be removed before the transformer is used for accurate measurement. Three of the methods by which this may be done are as follows:

(1) Pass full-load alternating current through the primary winding, with the secondary winding open, and gradually but smoothly reduce the current to zero.

(2) Pass full-load secondary current (usually 5 amperes, a.-c.) through the

MANUFACTURERS' NEW LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

B90 **Microscope Objectives and Eyepieces.** 20-page booklet combines technical discussions and descriptions of products. Carl Zeiss, Inc., New York City.

B91 **Barometer and Wind Indicator.** Folder titled "Old Superstitions" describes the "Weatherman," a luxurious brass-dial mahogany-case instrument combining aneroid barometer and electric remote-reading wind direction and velocity indicator. Julien P. Friez & Sons, Inc., Baltimore, Md.

B92 **Relays.** 24-page Catalog B describes, in addition to regular line of relays, new types of units, thermostats, time delay devices, counters, etc. Struthers Dunn, Inc., Philadelphia, Pa.

B93 **Extensometer.** Circular , gives technical description of "featherweight" extensometer especially applicable to fine wires and strips. Louis C. Eitzen Co., New York City.

B94 **Sperry Detector.** Vol. IV, No. 1 is entirely devoted to finding fissures in rails. Sperry Gyroscope Co., Brooklyn, N. Y.

B95 **Diaphragm Motor Valves.** 4-page "Supplement R" describes "Synchro" valves, reports tests demonstrating identical ascending and descending curves of pressure **vs.** position. The Bristol Co., Waterbury, Conn.

B96 **Scientific Instruments.** 5 new circulars (in English) on galvanometers, vacuum thermocouples, electrometer triodes, etc. P. J. Kipp & Zonen, Delft, Holland.

B97 **Humidistats.** 4-page Bulletin K lists new models, also transformer sets, kindred devices, and a new strip chart recorder for humidity, temperature and operation records. Julien P. Friez & Sons, Inc., Baltimore, Md.

B98 **Checking Percentage Modulation with the Cathode Ray Oscillograph.** Bulletin. Allen B. duMont Labs, Upper Montclair, N. J.

B99 **Gasoline Tests.** Revised Bulletins 131 and 146 announce improved equipment for A.S.T.M. and other tests for preformed gum, gum stability and Reid vapor pressure. American Instrument Co., Washington, D. C.

B100 **Current Meter Notes.** Reprint of article by E. F. Hoff. Scientific Instrument Co., Berkeley, Calif.

B101 **Graphic Arts Gage.** Circular describes self-aligning "Universal Gauge" for flat and curved stereotype plates, depth of halftones, etc. H. C. Zenke, Richmond Hill, N. Y.

B102 **Industrial Bulletin.** December issue's leading article is on high-speed photography. Arthur D. Little, Inc., Cambridge, Mass.

B103 **Electrical Instruments.** 8-fold folder pictures and describes mfr.'s line. The Triplett Electrical Instrument Co., Bluffton, Ohio.

B104 **Flow Meters.** Broadside titled "From One Engineer to Another" reproduces testimonials wherein engineers describe economies. The Brown Instrument Co., Philadelphia, Pa.

B105 **Bath Thermometers.** Folder pictures and describes various types. Taylor Instrument Companies, Rochester, N. Y.

B106 **Step-down Transformers, Variable Voltage Adjustors** are described by Bulletin 129. Acme Electric & Mfg. Co., Cleveland, Ohio.

B107 **Experimenter.** Jan.-Feb. issue has articles on recent developments in frequency standards, Variacs, wave analyzers, etc. General Radio Co., Cambridge, Mass.

B108 **Micro-manipulator.** 6-page Bulletin D132 describes the new Fitz instrument taking any microscope. Bausch & Lomb Optical Co., Rochester, N. Y.

B109 **Graphic Records.** Form 440 reports benefits derived through graphic meters in a cement plant. The Esterline-Angus Co., Indianapolis, Ind.

B110 **Control Relay Sets.** Bulletin IC33 describes new models. Signal Engineering & Mfg. Co., New York City.

B111 **Recording Potentiometer.** Bulletin 1077 describes photoelectrically balanced industrial strip-chart recorder. C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

B112 **Electric Motors.** Bulletins L20604, L20605 and L20606 describe new line of fractional-h.p. motors; 4-page Bulletin L20530B describes complete line of explosion-resisting motors. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

B113 **Small Oil Circuit Breakers.** 40-page Catalog 33-200 covers complete line of oil circuit breakers up to 50,000 kva., includes many tables, technical data. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

B114 **Electric Valves.** Bulletin I describes new line of ball-relay valves. A. F. Hoppe Engineering Co., Indianapolis, Ind.

B115 **Loupes.** 4-page bulletin describes jewelers' loupes. Bausch & Lomb Optical Co., Rochester, N. Y.

B116 **Molded Bakelite.** A 48-page booklet replete with illustrations of the latest achievements in Bakelite molding materials. Very interestingly written and contains much technical information. Bakelite Corp., Bound Brook, N. J.

B117 **Welding Timer.** Illustrated 4-page leaflet entitled "Ignitron Welding Timer for Spot Welding." This electronic controller is suitable for use in spot welding production work for joining all types and forms of materials. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

B118 **Hydrogen Ion Meter.** Bulletin 850 describes and illustrates the Acree universal pH meter, a portable meter for field, plant and laboratory work. Electrode assemblies and accessories are also illustrated. American Instrument Co., Washington, D. C.

B119 **Thread Measuring Machine,** developed by the Société Genevoise d'Instruments de Physique, is described in a 4-page reprint of an article in *Machinery*, London. R. Y. Ferner Company, Investment Bldg., Washington, D. C.

B120 **Binoculars.** A broadside and circular illustrate the 6 and 8 power binoculars. Prices given. Bausch & Lomb Optical Company, Rochester, N. Y.

B121 **Field Glasses, Telescopes, Microscopes and Magnifiers.** Catalog No. 10 is a 20-page booklet illustrating and describing the above products. Wollensak Optical Company, Rochester, N. Y.

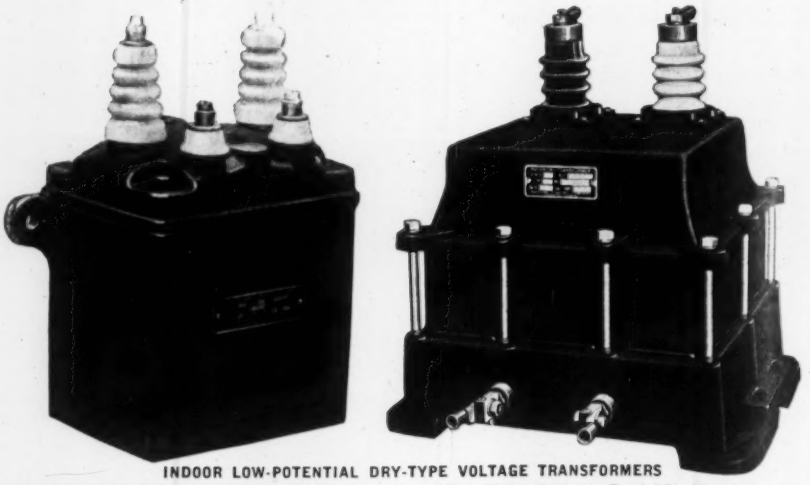
B122 **Combustion Meter.** Catalog RA-34 covers meters for CO_2 only and CO_2 combined with records of overfire draft and flue gas temperature. Forty-five types and combinations of CO_2, draft and temperature records are indicated. The Hays Corporation, Michigan City, Ind.

B123 **Supervisory Control.** Two wire viscode and audicode supervisory control are described in a 10-page publication. This means of obtaining remote indication of apparatus units is applicable for railroad, central station, substation, and oil and gas pump line operation. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

B124 **Resistance Thermometers.** Catalog No. 9001 is a new 32-page book covering Brown indicating, recording and controlling resistance thermometers for measuring temperatures from —300° to +1000°F. Brown Instrument Company, 4482 Wayne Ave., Philadelphia, Pa.

B125 **Supplementary Catalog of General Radio.** Part 2 of Catalog G was issued in March 1934. It covers: industrial devices, resistance devices, condensers, frequency and time measuring devices, oscillators, bridges and accessories, standard signal generators, oscillographs, audio-frequency transformers, and accessories. It has 44 pages. General Radio Company, Cambridge A, Massachusetts.

B126 **Potentiometer Stabilog.** Bulletin No. 191-1, a four-page circular illustrates the operation of the potentiometers Stabilog. Foxboro Company, Foxboro, Mass.



INDOOR LOW-POTENTIAL DRY-TYPE VOLTAGE TRANSFORMERS

Fig. 32-7. Weston Model 250, Type I. 50 to 133 cycles, 115-volt secondary, 500 va. capacity. Accuracy within 1%.

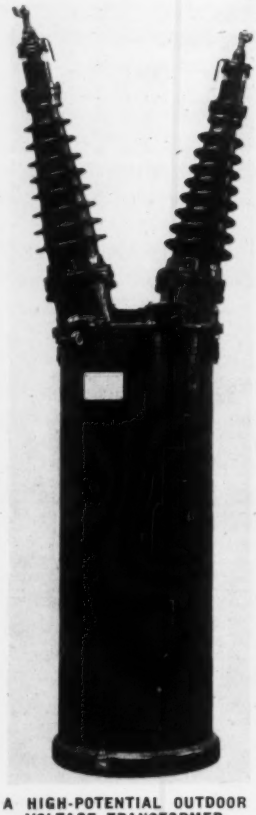
Fig. 32-8. Sangamo Type OC. 25 or 60 cycles, 115-volt secondary, 200 va. capacity. Accuracy ± 0.5% ratio and ± 20′ phase angle.

secondary winding with the primary winding open, and gradually reduce the current to zero.

(3) Pass full-load alternating current through the primary winding, with a resistance of several thousand ohms in the secondary circuit, and then rapidly and smoothly reduce the resistance to zero.

7. Special Types of Current Transformers

Little need be said, in this text, about the appearance and construction of regular (or normal) and special types of voltage transformers, or even of regular types of current transformers, because these details are seldom of interest to the user. A selection of large and small instrument transformers is presented in the illustrations herewith.



A HIGH-POTENTIAL OUTDOOR VOLTAGE TRANSFORMER

Fig. 32-9. General Electric Type E-116: oil-filled for 66,000 volts; 500 va. rating; 60 cycles; 110-volt secondary. Approx. 1/30 actual size.

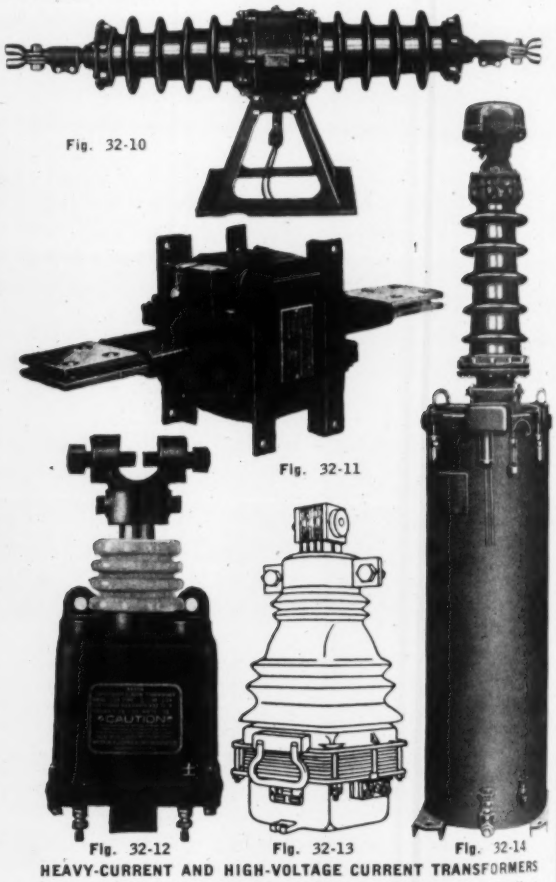


Fig. 32-10

Fig. 32-11

Fig. 32-12

Fig. 32-13

Fig. 32-14

HEAVY-CURRENT AND HIGH-VOLTAGE CURRENT TRANSFORMERS

Fig. 32-10. Outdoor dry-type, 15,000 to 45,000 volts (Westinghouse). Fig. 32-11. Indoor bar-type for 15,000 volts (General Electric). Fig. 32-12. Switchboard dry-type, 6600 volts (tested to 20,000), 5 va. capacity (Weston). Fig. 32-13. Portable sand-filled 3-range type tested to 64,000 volts (Siemens & Halske: H. H. Sticht & Co.). Fig. 32-14. Outdoor oil-insulated type for 46,000 volts (Westinghouse).

Fig. 32-15

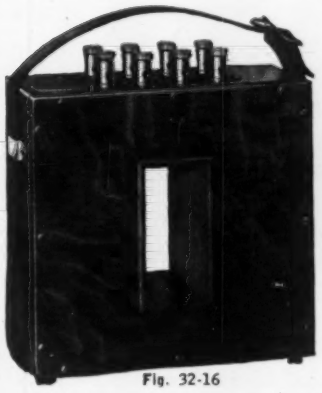


Fig. 32-16

Fig. 32-17

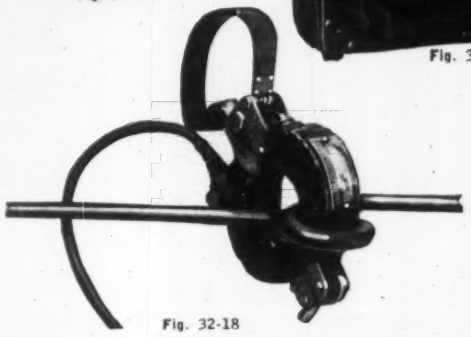


Fig. 32-18

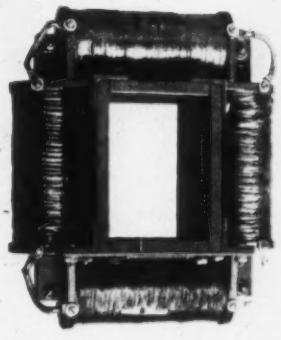


Fig. 32-19

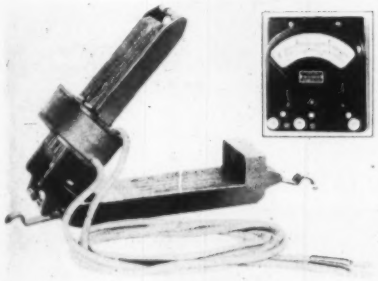


Fig. 32-20

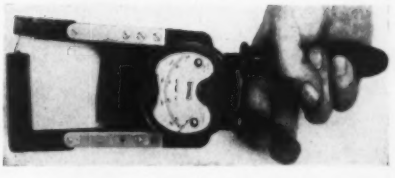


Fig. 32-21

MISCELLANEOUS PORTABLE AND SWITCHBOARD DRY-TYPE CURRENT TRANSFORMERS

Fig. 32-15. The new (1934) Model 327 portable precision combination variable-ratio type and "through" type current transformer, 25 to 60 cycles, 5 amp. max. secondary (Weston).

Fig. 32-16. Another new portable "through" type current transformer. 22 ratios are available without exceeding 12 primary turns, and with a single primary turn 7 ratios are available through secondary taps (Weston).

Fig. 32-17. Switchboard "through" type current transformer, 25 to 133 cycles, 40 va. capacity, 5 amp. max. secondary, line voltages up to 6600 volts (Weston).

Fig. 32-18. Hinged-core current transformer, part of an industrial test kit for measuring current in insulated conductors without interrupting service, shown with two primary turns through it, doubling ammeter reading (General Electric).

Fig. 32-19. Indoor metering transformer, for mounting over rectangular bus-bar carrying up to 5000 amperes; 25 va. capacity for watthour meters, higher for indicating instruments used with correction curves (Westinghouse).

Fig. 32-20. Test set having a hinged-core transformer for slipping over conductor without interrupting service. The "Type CSO" transformer weighs only 4½ lbs. (Roller-Smith).

Fig. 32-21. "Clip-on Ammeter" with hinged-core transformer forming part of device (Ferranti).

When we come to current transformers, however, we immediately note that distinctive and interesting types have been developed to meet special requirements. Some current transformers are not provided with a primary winding, this being made up by the user as required, by inserting one or more turns of the conductor carrying the current to be measured; and some portable forms are furnished not only with a primary winding, the number of whose turns may be varied to suit conditions, but also with an opening through which one or more turns of the line conductor may be linked with the core. These types of transformers make for great convenience and flexibility in general testing and, when properly designed, may be used with a degree of accuracy as high as that of the types having permanently wound primaries. The *hinged-core* type of current transformer is intended particularly for use where it is impracticable or undesirable to open the line for insertion of the transformers. Owing to the relatively high reluctance of the magnetic circuit in these types, it is generally considered unwise to make use of them for measurements except those of current and then only with specially calibrated ammeters and leads.

An interesting application of the hinged-core current transformer is found in some English instruments, such as the Ferranti "Clip-on" type, wherein the transformer and ammeter are incorporated in a single unit, to be clipped about the conductor by a conveniently located handle, Fig. 32-21. This instrument, however, must be distinguished from the "Tong Test," mentioned

B127 **Recording Densitometer.** Type PHE-1 describes a photo-electric densitometer developed by Weigle. The instrument is used for the study of various kinds of spectrograms. R. Y. Ferner, Investment Bldg., Washington, D. C.

B128 **Barcroft-Warburg Apparatus** for biochemistry and chemical analysis is covered by Bulletin 800. American Instrument Company, Washington, D. C.

B129 **Hour Counter.** Circular K-10 describes the Weston Model 691 hour counter, a compact integrating device for indicating life of units which have a rather definite life in hours of operation and which it is desirable to replace at the end of the indicated life rather than to wait for complete failure to require replacement. Weston Electrical Instrument Corporation, Waverly Park, Newark, N. J.

B130 **Electric Temperature Regulators.** Bulletin 101-3-34 covers the type E Heat Motor for use with thermostats with valve position either open or shut. Bulletin 102-3-34 covers the type C Heat Motor and has six intermediate valve positions between open and shut. Wilbin Instrument Corporation, 40 East 34th St., New York, N. Y.

B131 **The Electric Eye.** A 30-page booklet which gives a brief history of selenium and describes the Acousto-Lite Selenium Cell. Price 25 cents. Acousto-Lite Corp., Ltd., 2908 S. Vermont Ave., Los Angeles, Calif.

B 132 **Chromalox Heating Units.** Catalog 34 gives information on different types of heating units, installation instructions, suggestions and drawings showing best methods of installing, tables and charts giving types, sizes and ratings of heaters. 56 pages. Edwin L. Wiegand Co., 7500 Thomas Blvd., Pittsburgh, Pa.

B133 **Dynamic & Magnetic Speakers.** Bulletin S 2343 is a 4-page folder illustrating and describing speakers. Arlab Manufacturing Co., 1250 North Paulina St., Chicago, Ill.

B134 **Constants for Sine Bar.** The sine bar is used either for measuring angles accurately or for locating work to a given angle. This 6-page leaflet gives the constants for the different angles. Ford Motor Co., Johansson Division, Dearborn, Mich.

B135 **Fritted Glass Filters.** Catalogue 232 LE illustrates filtering crucibles, filter funnels, filters for mercury, filters for micro-chemistry, for gases, gas washing bottles, also precision-bore tubing. 24 pages. Fish-Schurman Corp., 230 East 45th St., New York, N. Y.

B136 **Paper Testing Instruments.** Leaflet P-340 illustrates a complete line of paper testing instruments. Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa.

B137 **Electric Heating Units and Devices.** Catalog GES-787B gives data on these units and illustrates glue pots, air heaters, melting pots, soldering irons and control equipment. General Electric Company, Schenectady, N. Y.

B138 **The Alloy Pot.** Vol. 2, No. 1, illustrates and discusses many applications of zinc die castings. New Jersey Zinc Co., 160 Front St., New York, N. Y.

INSTRUMENTS, 330 W. 42nd St.
New York City

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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NEW INSTRUMENTS

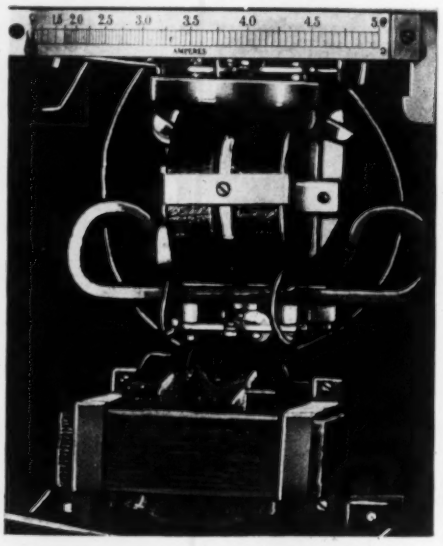
Write Information Section, Instruments Publishing Company, for additional information.

Electronic-relay-operated Potentiometer Pyrometer

Bailey Meter Co.

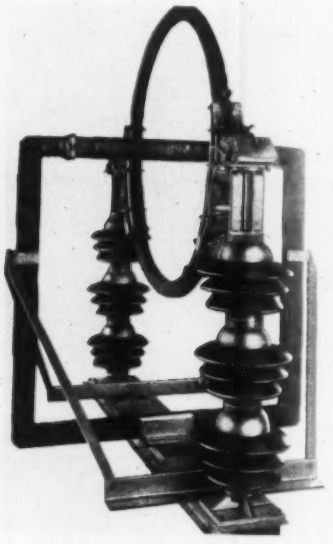
NAMED "Galvatron" after the galvanometer-electronic relay circuit which it employs to operate slide wire resistances and recording pens, this new potentiometer pyrometer may include as many as four potentiometer circuits, the contact-making galvanometer being automatically switched from one circuit to the next by relays actuated from contacts made by a timing commutator. One amply powerful synchronous motor drives not only these timing contacts for the relay, but also the galvanometer contacting mechanism, the recording chart, and the automatic standardizing relay contacts. The Galvatron mechanism consists of a galvanometer of short period arranged to make contacts of a duration proportional to the deflection of the galvanometer needle away from the null point. These contacts, which close the circuit to the electronic relay, carry only a few micro-amperes of current, and are connected to the grids of Pliotron tubes. Each galvanometer contact permits a flow of direct current through one Pliotron tube and the d.-c. winding of its transformer, the secondary of which is in series with one field coil of a reversible synchronous motor driving the individual potentiometer slide-wire unit. This flow of direct current permits a flow of alternating current through the transformer and field coil, thereby rotating the motor in one direction. Rotation in the opposite direction is produced in the same manner by energizing the other field coil through a second electronic relay when the galvanometer needle swings to the other side of neutral. Split-second operation of the reversing synchronous motors is obtained by the use of the Galvatron circuit, since the electronic relays act instantaneously in accordance with the galvanometer contacts. Because of the extremely small current flow required to operate the electronic relay, it

Fig. 1



A BUILT-IN CURRENT TRANSFORMER

Fig. 32-22. Electrodynamic movement of strip-chart recording ammeter with built-in current transformer. Primary winding is adapted to be supplied from regular 5-ampere metering circuits while secondary passes through the measuring element a current sufficiently small to be carried directly into moving coil.



AN AIR-INSULATED TRANSFORMER

Fig. 32-23. Core is large rectangle of iron plates, secondary coil wound on one leg. Primary coil is a ring which passes through center of rectangular opening, with leg bearing secondary winding concentric with primary (Niagara Elec. Imp. Corp.).

in Chapter XXXI, in which the magnetic circuit of the instrument proper is made to include the conductor in which current is to be measured.

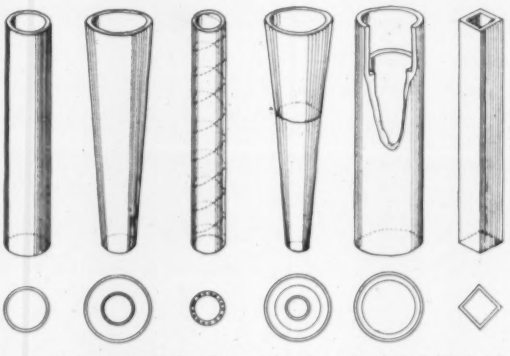
An inexpensive current transformer for use on high voltage circuits and particularly well suited to out-of-door installations is the air-insulated type, Fig. 32-23, manufactured by the Niagara Electric Improvement Corp. While this type of transformer is for use with ammeters and protective devices, it may also be compensated to give satisfactory accuracy when used with wattmeters.

Combination outfits—For convenience and efficiency in metering installations requiring both current and voltage transformers, particularly for out-of-door stations, there are available "outdoor metering outfits," which include both types of transformers permanently installed in a weatherproof cabinet with provision for such instruments and meters as may be required.

JENA KPG

Precision-bore Tubing

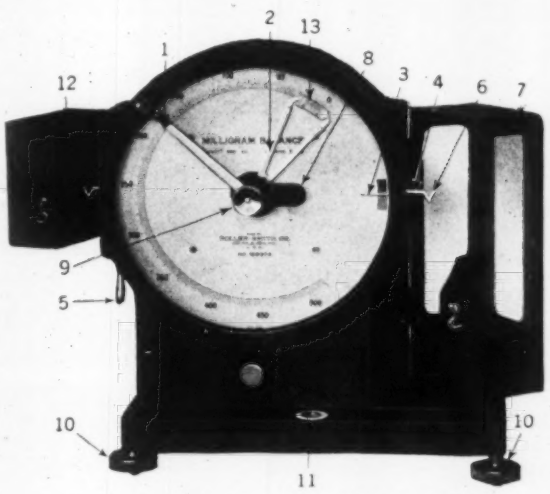
Bore exact within ± 0.001 mm. (0.00025") Smallest bore 0.5 mm., largest bore 50.0 mm.



Inside surface is clear like regular transparent glass tubing.
Bore of any cross-section: round, oval, square, etc., conical shaped tubing.
For barometers, viscosimeters, flowmeters, syringes, pumps, bearings, etc.

Sole Agents:

FISH-SCHURMAN CORP., 230 E. 45th St., N. Y. C.



500 mg. Model B Precision Balance With Double Hook for Increasing Range to 1000 or 1500 mg.

ROLLER-SMITH Model B
Precision Balances

are recommended for the *rapid* and *accurate* weighing of objects of *any* kind over a range of .002 milligram to 50 grams; also for rapidly determining the surface tension and specific gravity of liquids.

They are easy to operate, direct reading and very rugged. The object to be weighed is hung on the hook (6), the beam lock (5), released, the index lever (1), moved until the small pointer (3) is at zero and the weight of the object then read *direct on the dial.*

They are used by the Bureau of Standards and by many leading educational institutions, hospitals and industrials.

Send for Bulletin J-240 which gives full details and the outstanding features corresponding with the numerals shown in the cut at the left.

ROLLER-SMITH COMPANY
Electrical Measuring and Protective Apparatus

MAIN OFFICE
2132 Woolworth Bldg., New York

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Bethlehem, Pa.

Offices in principal cities in U.S.A. and Canada.

is possible to use light pressures on the galvanometer contacting mechanism without danger of burning. It is said that failures to make contacts (on account of increased resistance caused by dirt or oxide at the contact points) are never experienced. A further advantage gained by the use of light contact pressure is the minimizing of strain on the galvanometer needle and suspension ribbons. This permits minimizing the weight of the galvanometer needle, thereby obtaining extremely short galvanometer period and unusually high operating speed.

Automatic standardization takes place approximately every four hours at which time the dry cell is balanced against a standard cell. Contacts from the galvanometer, properly amplified through the electronic relays, effect this balance by the adjustment of a motor-driven resistance in series with the dry cell. A small indicator, visible from outside the hinged panel on which the Galvatron mechanism is mounted, shows the condition of the dry cell by a series of numbers, ending with a red signal which indicates that the cell should be replaced.

An outstanding feature of the Galvatron is that continuous records, up to four in number, are made on a round chart. When more than one record is provided for, inks of different colors are used, so that each record can be distinguished from the others no matter how many times they cross one another on the chart. All records of a multi-pen Galvatron recorder are continuous, although the contacts made by the single galvanometer needle are commutated among the potentiometer units in sequence. In the single-pen recorder, all contacts made at the galvanometer serve to balance the single potentiometer, which in this case is balanced every four seconds if necessary. In a 4-pen recorder, each potentiometer performs a measurement every 16 seconds, so that each record is smooth and continuous even when a 12-hour chart rotation period is desired.

Fig. 2 shows a calibrated slide-wire unit with reversing motor drive. (This is a pen-drive unit for a recording instrument: a slight modification converts it into a pointer-drive unit for an indicating instrument.) Fig. 3 shows a 4-pen recorder opened for inspection of the Galvatron relay mechanism and of the four units, all of which are assembled on a hinged aluminum panel. The recorder case, of pressed steel, is the makers' standard case used for housing their flow meters and other recorders. It is suitable for flush or panel mounting and is dust- and moisture-proof. Added protection for the galvanometer and contactor, and for the relays, is afforded by the two glazed enclosures seen in Fig. 3.

The makers also announce thermocouples and protection tubes, and resistance bulbs. With resistance elements, temperature measurement is effected by using a Wheatstone bridge circuit Galvatron. Compensating devices and other accessories, incident to the use of either thermoelectric or resistance elements, are furnished.

Fig. 2

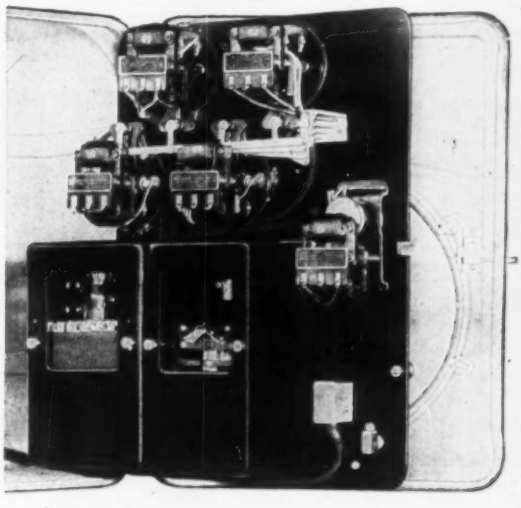


Fig. 3

Pocket-Size Light Meter
Westinghouse Elec. & Mfg. Co.

WITH this new light meter, surveys of illumination intensities in offices, factories, and homes can be readily made. The photox cell generates a current proportional to light

intensity falling on the face of its disk. This current is measured on the indicating instrument. The cell is hinged and can be placed in a horizontal plane with the instrument vertical so that it can be read without casting a shadow on the cell.

Gas Fractionating Units

Podbielniak Industrial Research Labs.

LIQUID air or CO_2 is the refrigerant used in this new line of units, whereby a complete analysis of any gas or vapor mixture is made by the method of condensation followed by precisely controlled fractional distillation. Among these new units are Model J (Fig. 1) which is a simplified form of this manufacturer's Model A; and Model K (Fig. 2) which has been brought out

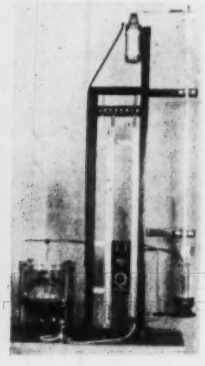


Fig. 1

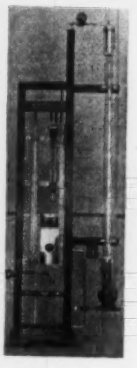


Fig. 2

to permit using liquid CO_2 instead of liquid air as the refrigerant, and is said to be so simple of operation that it may be used for routine plant work.

Expansion Valve. There is also announced a stainless steel CO_2 expansion valve and connections (Fig. 3) especially designed for use with Model K but said to be suitable also for laboratory refrigeration work.

Constant Level Mercury Manometer (Fig. 4). This is designed for use with fractionating units when the volumes of the gases being measured are small: it does not affect these measured volumes as would an ordinary mercurial manometer. Nevertheless, the visible differ-

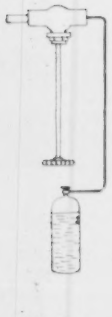


Fig. 3

Fig. 4

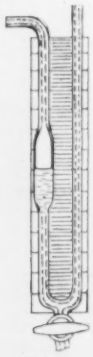


Fig. 5

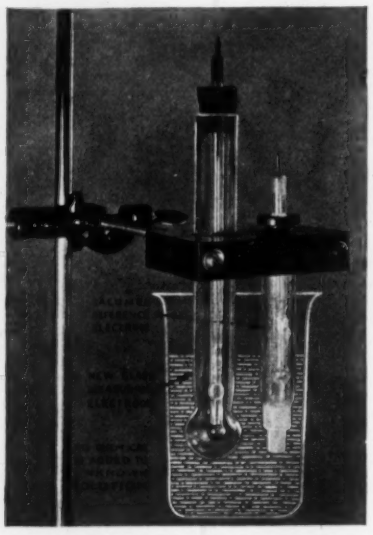
ence in mercury levels equals the difference between the system pressure and the atmospheric pressure. Additional lines are etched whereby compensations are made for variations in barometric pressure.

Differential Pressure Manometer (Fig. 5). Low dead space capacity is the chief design feature, making this new instrument applicable as a reflux cooling and heat supply indicator by connecting it to the top and bottom of the fractionating column. It is said to offer unique possibilities on applications other than fractionating apparatus where pressure differentials have to be measured precisely.

Glass pH Electrode

Leeds & Northrup Co.

FOR laboratory determinations, this new glass electrode enlarges the list of solutions whose pH can be measured with an ordinary potentiometer, because it functions in unbuffered, oxidizing or reducing solutions. Distilled water, the various bleaches, dyes, etc., are thus

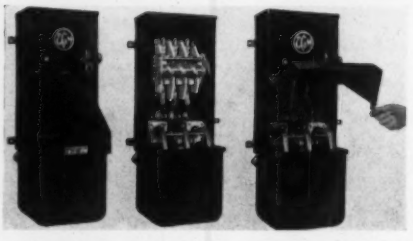


now included for the first time among the solutions that may be measured easily and accurately. The electrode has a range of 0-12.5 pH. It is used for pH indication without vacuum-tube or other amplifiers, and requires only a reflecting galvanometer of ordinary sensitivity for the detector in the potentiometer equipment.

Magnetic Starter

The Electric Controller & Mfg. Co.

FOR motors up to 30 hp., 220 volts, 60 hp., 440 volts, and 75 hp., 550 volts, the new EC&M No. 2 Type ZOS oil-immersed, across-the-line, combination magnetic starter contains an unfused or fusible safety switch and a magnetic starter with overload relays. All of the internal wiring is complete. Although designed for severe service these starters are small and narrow, having safety

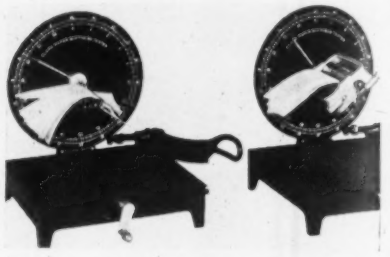


switch front operated and a cover that swings vertically, making them suitable for mounting in restricted spaces such as between the flanges of columns, etc. Extremely sturdy construction is said to be used throughout these starters: safety switches having wiping wedge, double-break contacts, heavy gauge steel parts with all actuating parts case-hardened; magnetic starters have bushed arm bearings, are quiet in operation and have larger-than-average clearances between live parts and high arc rupturing capacity.

Paper Softness Testers

Thwing Instrument Co.

TWO new paper softness testers are announced, one (at left in illustration) for routine testing and the other for research work, and preliminary exploratory work to secure data on which the work of the routine softness tester is applied. In the routine tester the samples are held fast by a flat spring with a snap clasp: the material under test is extended beyond

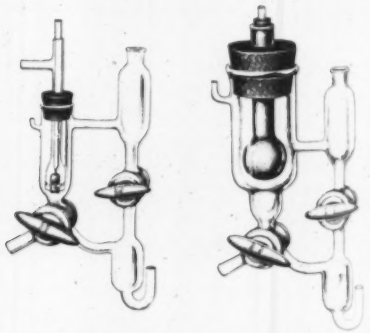


the clasp for a distance of 3.75". In the tester at the right the length of overhang of paper is adjustable through the rollers and is accomplished by a screw and worm at the front of the roller housing. In this laboratory instrument the adjustability is for determining values and setting standards of softness for various grades of paper. *Method of use* (for both): The sample of paper is rotated by means of the handle at the front of the tester. When the maximum softness (or stiffness) of the paper is reached, the paper falls; the paper is then rotated in the opposite direction until it falls; the total angle that the paper falls in both directions is used to denote the softness value. The instruments are self-contained, mounted on a metal base, the right hand edge of which is used for cutting the samples.

Glass Electrode Assembly

American Instrument Co.

CALOMEL reference cell and unknown chamber are combined in one piece of glassware, in this new line of compact electrode assemblies for pH work. An especially convenient assembly, it is said, is the one in which either glass,



hydrogen, or quinhydrone electrode can be used, which requires a sample of only 2 to 10 c.c. of liquid. These electrodes were designed for use with the maker's new Acree pH Meter described elsewhere in these columns, but it can be used as well with any potentiometer set-up for that type of electrode.

Portable Exhaust Gas Tester

By C. G. Thoma*

IT is well known that most automotive vehicles waste from 15% to 30% of the fuel supply by reason of improper engine adjustment, that continuous analysis of the exhaust gas is the quickest way to determine combustion efficiency, and that of the several methods of continuously indicating Air-Fuel Ratio by means of exhaust gas analysis, the simplest and most practical is that of electrically measuring the thermal conductivity of the exhaust gas in comparison with a standard gas of known value—air. Operating on this principle, the Cambridge Exhaust Gas Tester was especially designed for making continuous exhaust gas analyses on the road, with the vehicle carrying its usual load. Its use is simple: A tubular metal fitting at one end of a flexible hose is inserted into the tail pipe of the automobile under test. The other end of the hose is attached to the instrument. A continuous sample is thus led to the tester and, after diffusing into the test cell, is expelled at the side of the instrument. A flutter relief valve discharges any condensate which may accumulate, as well as the excess gas when the engine is operating at high speed. Within a few seconds after the gas has left the exhaust manifold, the result of the analysis is shown by the movement of the pointer over the instrument scale, which is calibrated in both air-fuel ratio and percent completeness of combustion. The new tester was especially designed for road testing, for it is common knowledge that the conditions of operation of the carburetor with an *unloaded motor* at 1,000 to 2,500 r.p.m. are greatly different from those of a motor under normal or heavy load at such engine speeds. Accordingly the proportions of air and gasoline supplied by the carburetor (air-fuel ratio) under the two sets of conditions are greatly different. A unique method of suspending the moving system of the galvanometer gives the Cambridge instrument the ruggedness necessary for road tests: The patented magnetically cushioned movement is so designed as to absorb severe shocks with minimum damage to the pivot points. The coil assembly, instead of being rigidly mounted and having to absorb shocks, floats in this magnetic field which, yielding gradually to road shocks and vibration, cushions the pivots from injury. It actually floats in the magnetic field as a cork does upon water. The coil is so damped that the pointer remains steady and readable under all conditions.

Provision is made for equalizing the humidity of the exhaust gas and the standard gas (air) by keeping the latter saturated to conform with the condition of the former. This eliminates any error due to variations in heat conductivity that would result if the air in the standard test cell were to change in humidity with atmospheric changes. The effects of temperature variation are nullified by mounting the gas analyzing cells in a solid block of metal. While designed for road work, the new Cambridge tester should also be of material help to the research laboratory.

*Cambridge Instrument Co., Inc., New York.

Air-Operated Temperature and Pressure Controllers

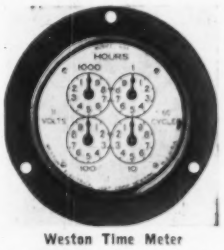
The Foxboro Co.

TWO new control instruments of practically identical appearance—Type 1119 for controlling temperature and Type 2119 for pressure—will be found particularly useful where dependable control at a definite control point must be provided inexpensively. The dial and knob on the lower face are for setting. The pressure gage indicates the air pressure on the diaphragm-motor of the control valve and thus shows whether the valve is opening or closing. On the temperature controller, a 2" dial type thermometer may be installed in place of this air gage and connected to the same bulb as the controller, thus showing the temperature being maintained. The pressure controller may be equipped likewise with a high-pressure indicating gage that shows the pressure being controlled. In either case, it is necessary to mount a valve motor air gage on the air line to the valve outside the case. The universal case may be either flush or surface mounted. The connection may be top, bottom or back and the choice can be made on the job when the instrument is being set up which takes little time. All working parts are integral with or mounted on a cast aluminum base. By removing the setting knob set screw and two other screws, the entire case can be removed, leaving the interior open to inspection.

Elapsed Time Meter

Weston Electric Instrument Corp.

INSTEAD of waiting for equipment to break down or even to become less efficient than when new, modern practice dictates overhauling, servicing or parts-replacement after a definite number of hours. The new Hour Counter, applicable to any equipment where a circuit is closed during running time and open during idle time (or vice versa), indicates up to 9,999 hours and repeats, on a four-circle register shown here one-third actual size. The device weighs 18 oz., is 4½" deep overall with a 2¾" body diameter, and is regularly furnished for 110 volt, 60 cycle circuits (other electrical characteristics may be had). Standard applications already reported include radio stations where each class of tube must be replaced after so many hours.



Weston Time Meter

AUTOMATIC INSPECTION

for

size	color	hardness
shape	resistance	smoothness
defects	capacity	contour

IF any of your products is required to be uniform and is inspected

100%

and if such inspection consists of quantitative determinations of any kind, *we will undertake to furnish an automatic inspector.*

FOR EXAMPLE

We have built machines to check diameters within ±0.000025" at the rate of 120 per minute.

Sorting of carbon resistors, ½ of 1% accuracy, into 20 values, at 100 per minute.

Beans graded at 600 per minute.

One $3000 installation paid for itself in six weeks and has been in operation for over two years without a cent spent for repairs or replacement.

"It Can
Be Done"
"We Did It"

ELECTRONIC INSPECTION LABORATORIES

R. D. McDILL
Industrial Electronics Engineer

942 PROSPECT AVE., CLEVELAND, OHIO

Indicating, Recording and Integrating Fluid Meter

Morey & Jones, Ltd.

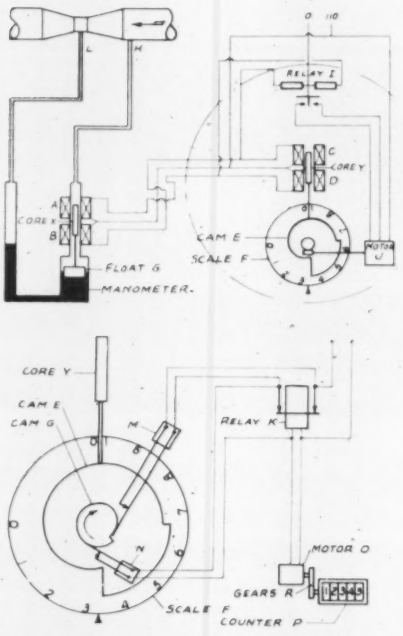
So sensitive is this new flow meter, it is said, that even when the primary element is an orifice or Venturi with square-law characteristic, accuracy is obtained at 5% of capacity, giving a 20 to 1 range of flow measurement. This is made possible by the patented electric circuit and other features described as follows: Operation is positive. There are no packing glands to cause friction; or clutches, ratchets and pawls to wear or slip. All elements are driven directly by motors of ample power. A weight of >1 lb. suspended from the pen arm at a radius of 1" has no effect upon the reading. The meter operates on 110-volt, 50 or 60 cycle, single phase a.c., and consumes 30 watts. Because of the inherently balanced circuit employed, voltage variations of ±15% in no way affect the operation. The super-sensitive relay used to control the cam shaft motor operates similarly to a galvanometer. Reliability is assured by the use of tungsten contact points making or breaking a very small current.

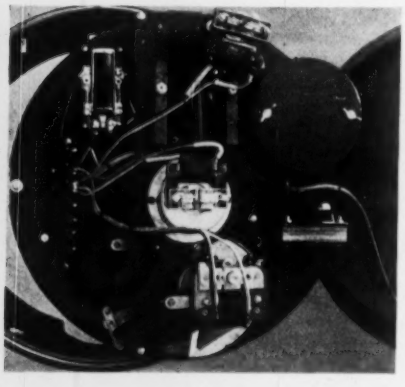
Flow Meter Principle: Differential pressure between H and L, a square root function of the rate of flow, is balanced by a mercury column. Float G riding on the mercury in one leg of the manometer positions core X inside coils A and B in relation to the differential pressure. Coils C and D and core Y in the instrument are exactly similar to coils A and B and core X in the manometer. Current through coils A and D passes through one side of the relay; current through coils B and C passes through the other side. Unless cores X and Y are in the same relative position the circuit is unbalanced, causing relay I to operate reversing motor J that turns cam E which raises or lowers core Y until its position is the same as core X. The cam extracts the square root of the differential so that the indicating dial, with uniform graduations rotating with the cam, shows directly the rate of flow.

Integrator Principle: Cam G revolves twice each minute. Contact M is stationary and starts motor O. Contact N revolves with cam E and indicating scale F and stops integrator motor. Relay K holds the circuit closed after contact M has opened and until cam G opens contact N. The time the integrator motor is operating is therefore directly proportional to the rate of flow.

The indicator, recorder and totalizer are all direct reading in any units specified. If a multiplier is used, it is ten or a multiple of ten. The indicating scale revolves through 270° and has an equivalent straight line length of 11". The 5-digit totalizer is driven directly by a small synchronous motor once every 30 seconds, giving an accurate integration of the flow. The charts are 12" in diameter, having uniform divisions; 24 hour or 7 day. All elements of the meter are mounted on a disk hinged to the inside of the case and may be swung out clear of the front for inspection. The case is of cast aluminum, weather-proof, surface mounted or flush mounted. Outlets for flexible or standard conduit are provided in the bottom of the case, one for connection to the power supply and one to the sending unit. Three wires are employed to connect the sending unit to the meter register which may be located any distance away, provided that the resistance of any one wire does not exceed 150 ohms. The manometer, of simple design, is adaptable to a wide range of differential pressures. A very small amount of mercury is required. Check valves integral with the float and core prevent mercury blow-over in either direction. Zero adjustment is accessible from the outside. The standard manometer is suitable for pressures up to 500 lbs. but can be furnished for 2000 lbs.

Float Unit: For metering flow through a Venturi flume or over a weir, the core is positioned by a float hung on a calibrated spring. This unit is adaptable to a wide range of levels, and is compact, having no gears, pulleys or cable.

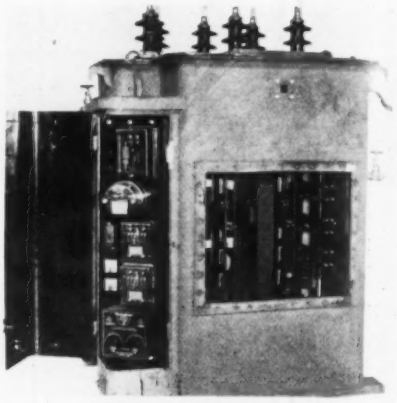




"Vitameter A"

Adam Hilger, Ltd.

Testing cod liver oil, etc., for vitamin A chromogen content is facilitated by this new instrument which measures the absorption of the solution for radiations in the immediate neighborhood of 3280 A.u. and employs the spectrophotometric method. Measurements are made visually with a photometric comparator whose scale gives readings that are a direct measure of the Vitamin A chromogen content. It is said the Vitameter A may be used at all stages of extraction, refining, blending and distribution, even by comparatively unskilled labor.



Voltage Regulator

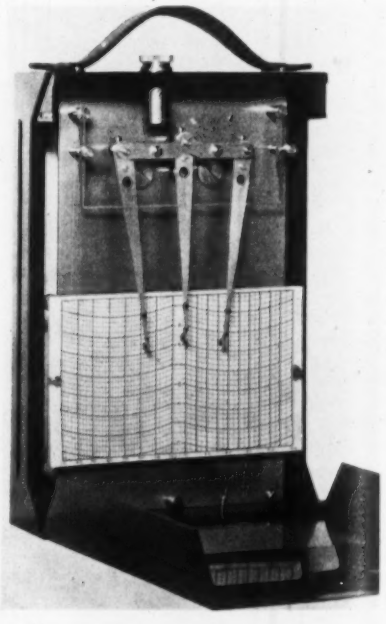
Westinghouse Elec. & Mfg. Co.

Economy in first cost, installation cost and operating cost is claimed for the new step-type UR voltage regulator for medium and high voltage rural or suburban lines (of 4800 volts or more). The weather-proof case contains everything required to provide step regulation of the voltage. The regulator being self contained and compact, installation cost is minimized. Low exciting current, low losses and surge proof design insure long life. While most common application is regulation of line voltage, Type UR can also be arranged to control phase angle of 3-phase circuits. Illustration shows accessory panel and tap-changing mechanism.

Temperature, Humidity and Operation Recorder

Julien P. Friez & Sons, Inc.

Designed for severe service, this new instrument is for use by those engaged in heating, ventilating, air-conditioning, refrigeration, etc., and for industrial plant applications. The model illustrated is for recording temperature, humidity and operations (on and off). Other models are for any two records, or only one. Instrument measures 8½"x5½"x2¼" and weighs 52 oz. Charts are unique: 3"x5" cards, which



travel down in a period of 10 or 30 hours, as specified, and can be filled in on the reverse just like index cards. Thermal systems are self-contained (no remote bulbs) with range of 0 to 110°F. or —30° to 80°F. Hygrometric elements are Friez specially treated human hair type, for 0 to 100% relative humidity. Operation recording elements have 12-ft. flexible leads, plugs, etc.

The "Fulscope" Temperature Regulator

By E. B. Foote*

IN most applications of temperature regulating equipment to industrial processes, the principal object is to control the temperature uniformly throughout the entire apparatus. Uniformity depends not only upon the regulator, but upon the time required for heat admitted at one or several points to travel through the apparatus and to affect the regulator bulb located at some other point. This apparatus lag is determined principally by three conditions, *viz.*, the location of the bulb with respect to the heat source, heat conduction, and circulation of the material the temperature of which is being controlled. These conditions are largely beyond the control of the instrument manufacturer. As a result of efforts to meet them, a variety of regulators having different sensitivities has been brought out.

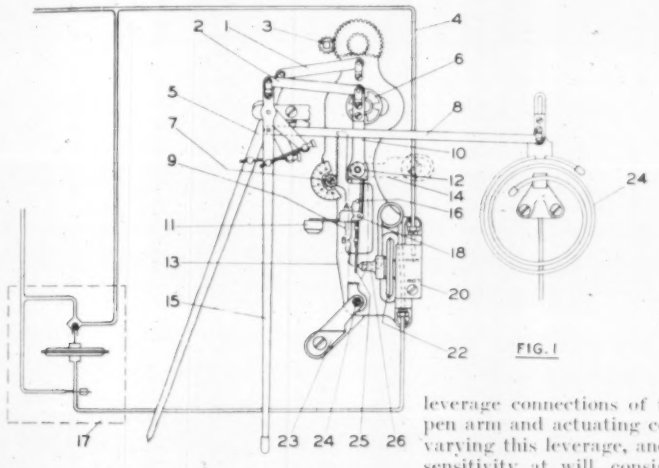


FIG. 1

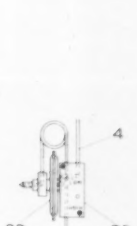


FIG. 2

The sensitivity of an air-operated recording regulator may be defined as the amount of temperature change, in terms of pen movement, necessary to cause one full stroke of the diaphragm valve. If such a full stroke results from a slight movement of the pen, the instrument sensitivity is said to be "high." If the required pen movement covers a considerable portion of the chart, the sensitivity is said to be "low." The most sensitive air-operated regulators, therefore, produce "on and off" action of the heat supply, while those of low sensitivity produce throttling or floating diaphragm-motor valve action. Some types of regulators can be adjusted for sensitivity over limited ranges. Other types cover a wider scope and have several fixed positions at which the sensitivity can be set.

There has now been developed a regulator which has in it a sliding adjustment providing a full scope of sensitivities, sufficient to meet the requirements of all industrial applications. It is made in either the recording or indicating type and operates on the familiar "nozzle and baffle" principle, utilizing the Taylor relay air valve well-known to *Instruments* readers. Referring to Fig. 1 (which is diagrammatic and somewhat distorted for clarity) operation is as follows: Motion of actuating coil 24 resulting from temperature changes at the instrument bulb is transmitted through link 8 to recording arm 15, thence by link 2 to control lever 10. This lever is mounted in cone pivots at 24 and carries on its reverse side pin 16. Against this pin bears the upper extension of baffle 25 held there by counterweight 11 on the left extension. The motion thus reaching the baffle causes variations in back pressure of an air stream flowing against it from nozzle 26. These variations are amplified by relay air valve 17 and utilized to effect control in the usual way by means of a diaphragm-motor valve or equivalent device.

The ratio of the extent of change in this back pressure to the amount of pen movement determines the instrument sensitivity. This ratio depends upon the leverage connections of the baffle to the pen arm and actuating coil. A means for varying this leverage, and thus adjusting sensitivity at will, consists of adjusting the baffle pivot 18 with respect to the nozzle and pin 16, the nozzle and pin remaining in fixed leverage relation to each other. This is accomplished by turning screwdriver adjustment 7, the motion being transmitted by pinion and rack to plate 9 on which the baffle is pivoted. (It will be seen that moment *A* is increased as moment *B* is decreased and vice versa, thus providing a greater range of sensitivity adjustment than would be possible if the baffle center were fixed and the nozzle made adjustable.)

While this arrangement covers all of the high sensitivity applications, there are many installations which require lower sensitivities. To provide for these, a low range adjustment is made available by reversing plate 20 as shown in Fig. 2. This allows air to flow into diaphragm 22 and being connected through tube 4 to the line leading to the diaphragm motor, causes the nozzle to move and to "follow" the baffle with a slight differential so that a greater baffle movement (and therefore a greater pen movement) is required to effect the proper back pressure change. The screwdriver adjustment of the baffle is also used to make changes in this low range of sensitivity. The high and low ranges overlap slightly, providing a full scope of sensitivities from less than 1/64" pen movement at the highest, to more than the chart width at the lowest.

To set the instrument to control at any desired point, it is necessary only to turn post 3 until indicator 5 coincides with that point. Motion of 3 is transmitted by gearing to lever 13 on which the baffle mechanism is mounted and thence through link 1 to the indicator. The pivot of lever 13 is in back of, and on the same axis as, pivot 24 of lever 10 so that "setting" motion of the baffle is a short arc whose center coincides with that of the "control" motion of pin 16 described above. Lever 13 is held wherever it is set by friction washer 6.

Levers 13 and 10 are each provided with two points, 12 and 24, at which they can be pivoted. They are shown held in bracket 23 by pivot 24 on the lower end, in which position the action of the regulator causes air to be applied to the diaphragm valve motor when the controlled temperature tends to rise too high. On some applications this action has to be reversed, *i.e.*, air applied when the temperature tends to fall too low. To accomplish this, bracket 23 is transferred to the position shown in dotted lines at 12, thus reversing the motion of the baffle with respect to that of the pen and actuating coil.

The regulator can be adjusted for sensitivity in either the high or low ranges without taking it out of service. It can almost be tuned in like a radio receiver. The action can be made either direct or reverse without the use of extra parts. The mechanism is so designed that two regulating units can be assembled into the same case, making a double-duty instrument.

With the use of suitable primary elements, it serves a full scope of control applications including temperature, pressure, fluid flow, liquid level and either compression or tension load. Any of these, moreover, can be made to follow a predetermined time schedule by the addition of a suitable cam mechanism. All in all, therefore, the new instrument is a "Fulscope" regulator in performance as well as designation.

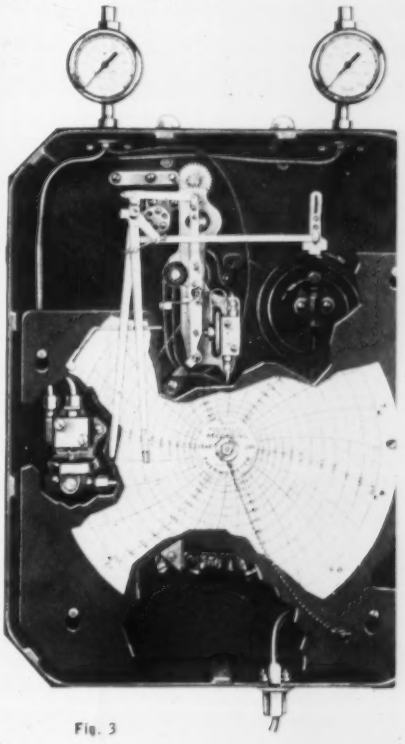


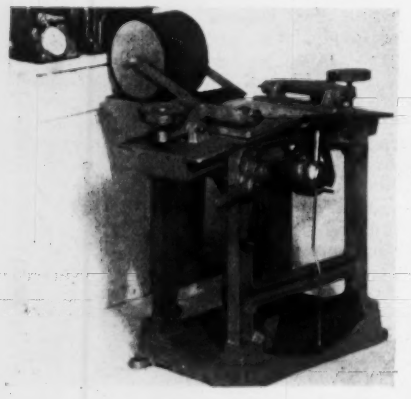
Fig. 3

*Designing Engineer, Taylor Instrument Companies, Rochester, N. Y.

Gummed Tape Tester

By A. S. Hall*

ELIMINATION of the human element from the several distinct steps incident to testing adhesive properties of gummed tape has at last been achieved. The need of a reliable tester arose from the fact that all previous



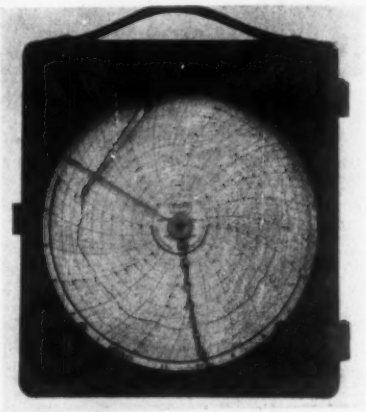
methods gave uncertain results even on successive portions of one uniform roll; previous readings were questionable, and previous instruments did not agree among one another. Not only will the new Improved McLaurin Gummed Tape Tester indicate equal scale values (±1%) for successive samples of a uniform roll, but it can be relied upon to detect and measure non-uniformity. Moreover, a number of Improved McLaurin instruments will give equal readings when testing a number of samples from one lot, discrepancies being attributable to differences in the specimens rather than to errors of calibration or manipulation. Illustration shows complete apparatus, *i.e.*, tester proper, tape holder-moistener, and stop-watch. A 6"x9" kraft sheet is held taut across the platens, gripped in the side jaws and slit with a knife in the space between the edges of the platens. The standardized procedure involves drawing a 5" sample, cutting it, starting the stop-watch, applying the sample, giving it two passes of the standard-pressure roller, and (when stop-watch reads 5 sec.) tripping the starting lever, releasing a pendulum which raises the platens and exerts a constant definite force on the tape. The resistance of the moistened glue just prior to complete set is indicated on the scale by the final position of the pointer. The actual test, therefore, is completely automatic. Comparative results indicated on the McLaurin scale are always directly proportional to one another: "90" indicates exactly three times the gummed tape strength indicated by "30" and for the first time it is possible to do away with loose terminology and state quantitatively that one brand possesses—for example—87% of the strength possessed by another. Every McLaurin Tester is graduated with the Thwing calibrating apparatus, checked with a special General Electric device (Gummed Industries Ass'n McLaurin symposium) and finally compared with a master tester used for no other purpose.

*Thwing Instrument Co.

Recording Thermometers

Moto Meter Gauge & Equipm't Corp.

EMBODYING thermal systems similar to those of the maker's line of dial-indicating thermometers, the new "Model 500" instruments are made in portable (illustrated) and wall types, both using 6" 24-hour charts and spring clockworks. Case dimensions are $7\frac{1}{4}$x7x$2\frac{3}{4}$". Portable model (with 5 ft. tube and standard bulb) weighs approximately 4

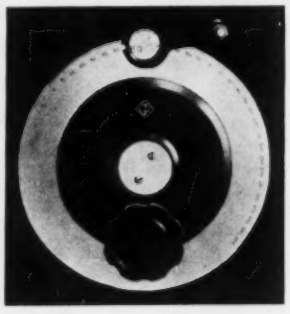


lbs. Twenty ranges are available between extremes of —40 and +350°F. Tube temperature error is said to be negligible and head temperature compensation is provided; and it is said moreover that "relative position of head and bulb will in no way affect recording correct temperatures." Various styles of tubes and bulbs are available, as well as separable sockets and other fittings.

Dependability

In selecting parts for instruments or test equipment, dependability of the part and of the source of supply is a primary consideration.

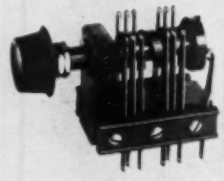
General Radio standard parts are developed by an instrument manufacturer of twenty years' experience for use in his own laboratory apparatus.



Slow-motion dials of several types are available. Precision type illustrated. Scales individually machine engraved.

Price

Type 704 (4")...$7.50
Type 706 (6")... 8.00
Type 519-A Lens 1.50



Multi-pole switch. Bakelite bracket. One-quarter turn of knob closes contacts.

Price

Type 339-A.....$2.50 (4-pole D.T.)
Type 339-B..... 2.00 (2-pole D.T.)

Illustrative of a complete line of instrument parts described in Catalog G-I.

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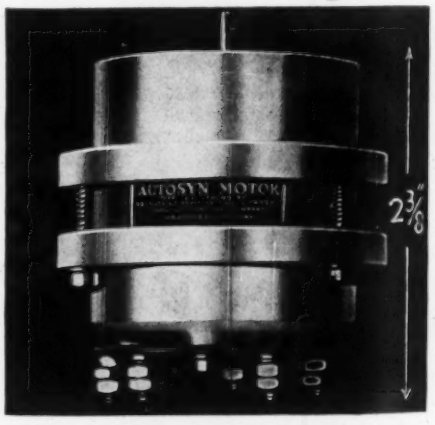
CAMBRIDGE MASSACHUSETTS

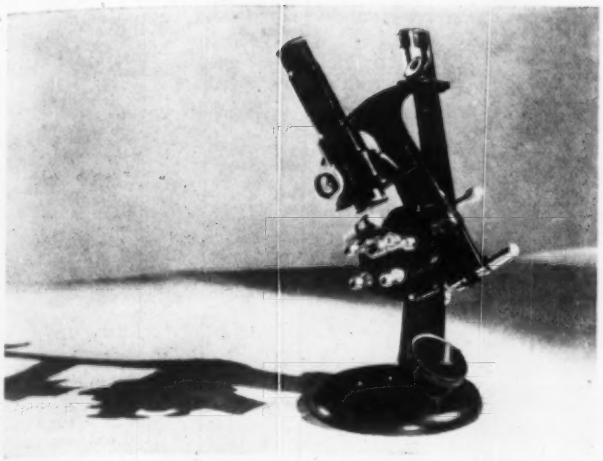
autosyn



Smallest self-synchronizing motor for remote indications

Unusually small dimensions, low weight and accurate response to delicate variations, qualifies AUTOSYN for hundreds of remote indicating applications. Write for data.

PIONEER INSTRUMENTS
PIONEER INSTRUMENT COMPANY INCORPORATED
Brooklyn · New York · A subsidiary of the Bendix Aviation Corporation



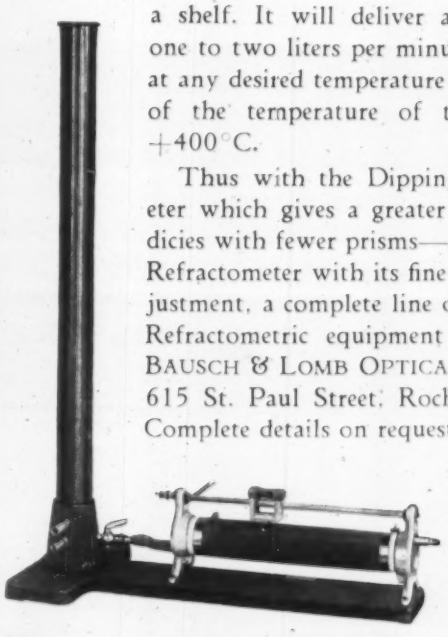
Temperature Control Accurate to ±0.1°C

With the advent of the B & L Temperature Control Apparatus, the Refractometer becomes an instrument with entirely new possibilities. Now for the first time temperatures accurate to ±0.1° C. can be quickly attained and constantly held.

This control makes possible a high degree of accuracy in analysis such as the determination of concentration of pure aqueous solutions of glycerol within 0.1 percent!*

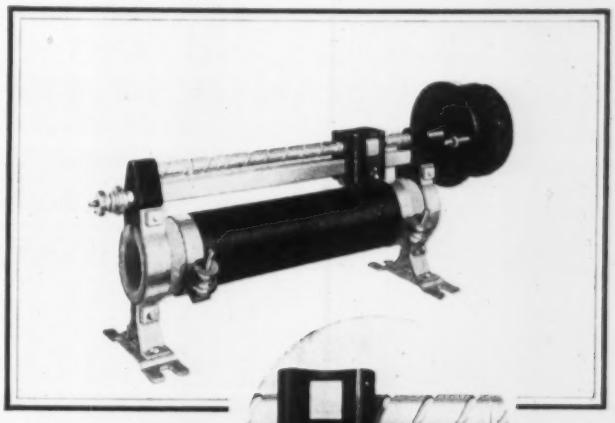
The equipment itself consists of a constant pressure tower, a valve to regulate the flow, and a variable electric heater. It may be set on the table or upon a shelf. It will deliver approximately one to two liters per minute of effulent at any desired temperature from +5° C. of the temperature of the input to +400° C.

Thus with the Dipping Refractometer which gives a greater range of indicies with fewer prisms—and the Abbe Refractometer with its fine degree of adjustment, a complete line of fine B & L Refractometric equipment is available. BAUSCH & LOMB OPTICAL COMPANY, 615 St. Paul Street, Rochester, N. Y. Complete details on request.

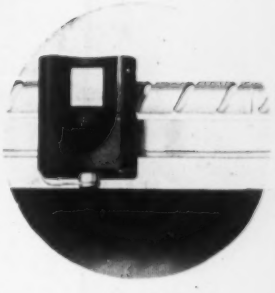


*See the article "New Table of the Refractive Index of Pure Glycerol at 20°C", by L. F. Hoyt, Industrial & Engineering Chemistry, March 1934.

Bausch & Lomb



Detail of slider showing silver single point contact.



Control to the Nth degree

. . . With the new silver single point contact . . . and the micro drive, notched handle

Right angle type micrometer drive.

Ward Leonard Sliding Contact Tubular Rheostats are precision instruments designed for the accurate control of currents up to twenty-five amperes and voltages within their ratings. The new contact with silver single point assures positive conductivity between the slider bar and the resistance winding. They include Rheostats in a wide range of resistance values, single and dual slider adjustment types, also micrometer drive. All are arranged for potentiometer connections.

Vertical type, single slider adjustment

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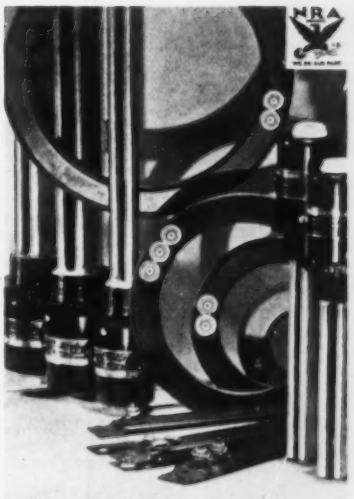

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